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ABSTRACT

Learning activity packages are presented for teaching tractor mechanics. The first of two sections deals with miscellaneous tasks and contains learning activity packages on cleaning the tractor and receiving new tractor parts. Section 2 is concerned with maintaining and servicing the electrical system, and it includes the following learning activity packages: testing the battery, servicing battery connections, activating a battery, charging a battery, testing the charging circuit, adjusting the voltage regulator, servicing the alternator, servicing the generator, replacing the amperage guage, servicing the ignition wires, servicing the distributor, testing the starter circuit, servicing the starter motor, replacing the starter motor, and replacing the ring gear on a flywheel. Typically the packages contain the following format: introduction, directions, objectives, learning activities, tools and equipment needed, materials and supplies needed, safety, instructions, student self-check, check-out activities, and instructor's final check list. The packages are illustrated. (CSS)

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# TRACTOR MECHANICS

## LEARNING ACTIVITY PACKAGES 1 - 19

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Cleaning the Tractor

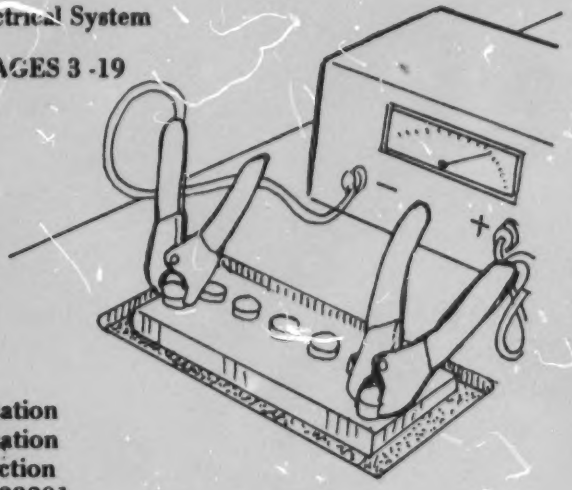
LEARNING ACTIVITY PACKAGE 1

Receiving New Tractor Parts

LEARNING ACTIVITY PACKAGE 2

Maintaining and Servicing the Electrical System

LEARNING ACTIVITY PACKAGES 3 -19



State Department of Education
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Columbia, South Carolina 29201

In Cooperation with

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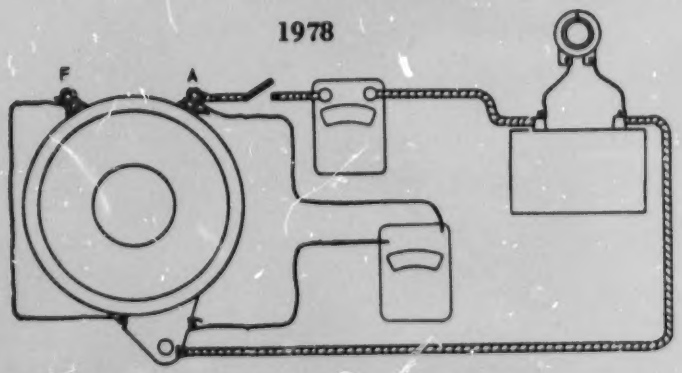


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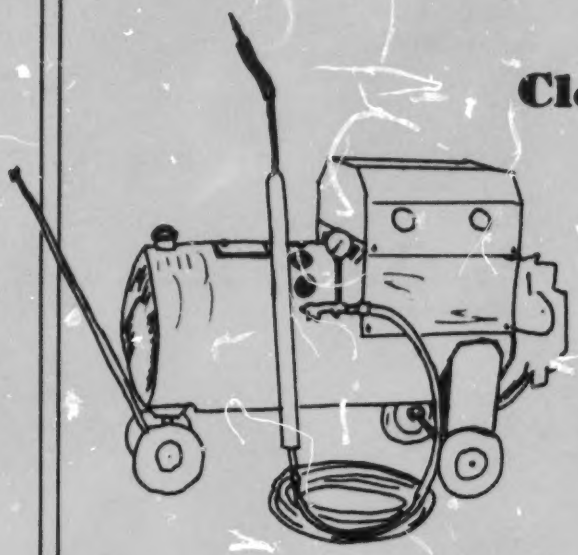
## TRACTOR MECHANICS

| Learning Activity Package Number | Objective Numbers | Learning Activity Package Title |
|---|---|---|
| **MISCELLANEOUS TASKS** | | |
| 1 | 6-7-8 | Cleaning the Tractor |
| 2 | 5 | Receiving New Tractor Parts |
| **DUTY: MAINTAINING AND SERVICING THE ELECTRICAL SYSTEM** | | |
| 3 | 25-26-27-28 | Testing the Battery |
| 4 | 24-29-30 | Servicing Battery Connections |
| 5 | 22 | Activating a Battery |
| 6 | 23 | Charging a Battery |
| 7 | 53-55-63 | Testing the Charging Circuit |
| 8 | 51-52 | Adjusting the Voltage Regulator |
| 9 | 58-60-61-62 | Servicing the Alternator |
| 10 | 54-57-59-64 | Servicing the Generator |
| 11 | 56 | Replacing the Amperage Gauge |
| 12 | 30-34-35 | Servicing the Ignition Wires |
| 13 | 36 | Servicing Spark Plugs |
| 14 | 40 | Servicing the Coil |
| 15 | 32-33-37-38-39-41 | Servicing the Distributor |
| 16 | 65-66-67-68 | Testing the Starter Circuit |
| 17 | 69-71-72-73 | Servicing the Starter Motor |
| 18 | 74 | Replacing the Starter Motor |
| 19 | 70 | Replacing the Ring Gear on a Flywheel |

# Learning Activity Package Number 1

Objectives 6-7-8



## Cleaning the Tractor

# Tractor Mechanics

### INTRODUCTION

After many hours of operation, tremendous deposits of oil, grease, and dirt will accumulate on the engine, transmission, differential, axles, and wheels of a tractor. To avoid contaminating the inner parts of a tractor during disassembly and repair, the tractor must be thoroughly cleaned with a steam cleaner. In this learning activity package you will learn how to use a steam cleaner to remove oil, grease, and dirt from a tractor that needs repair.

### DIRECTIONS

Read the objectives below. If you believe you are already able to perform these tasks, read the Check-Out Activities on page 4 of this package. Then, either arrange with your instructor about doing the Check-Out Activities,

or

If you need to complete the learning activities in order to be able to do the tasks, turn to p. 2 and go through the Learning Activities in the order given.

### OBJECTIVES

(1) Given a steam cleaner, power source, and water supply, prepare the steam cleaner for use. The preparation must include acceptable completion of all the steps on the instructor's checklist.

(2) Given a dirty tractor and a steam cleaner prepared for use, clean the tractor. Upon inspection the tractor should show no signs of dirt, oil, or grease.

(3) Following the use of the steam cleaner, prepare the cleaner for shut-down. The preparation must include completion of all points on the Instructor's Checklist.

## LEARNING ACTIVITIES

1 READ the manufacturer's instruction manual for the designated steam cleaner.

(or) _____

2 VIEW the slide tape presentation Learning Activity Package 1, "Using a Steam Cleaner," in the learning center.

(or) _____

3 IDENTIFY AND LOCATE on the steam cleaner, the water hose attachment, power cord, drain plug, fuel tank with filler cap, pump switch, burner control, and steam hose.

(or) _____

4 CHECK YOUR KNOWLEDGE of steam cleaning by taking the *STUDENT SELF–CHECK – CLEANING THE TRACTOR.*

5 READ *INSTRUCTIONS – A. PREPARING THE STEAM CLEANER FOR USE; B. CLEANING THE TRACTOR,* and *C. SHUTTING DOWN THE STEAM CLEANER.*

(or) _____

6 OBSERVE another student as he or she satisfactorily performs and is checked out on this learning activity package.

(or) _____

7 PRACTICE cleaning a designated tractor with a steam cleaner following the procedure outlined in *INSTRUCTIONS A, B, and C.*

8 ARRANGE with your instructor to complete this learning activity package by going through the CHECK-OUT ACTIVITIES listed on page 4.

## TOOLS AND EQUIPMENT NEEDED

1. Steam Cleaner

## MATERIALS AND SUPPLIES NEEDED

1. Water
2. Detergent specified by manufacturer of steam cleaner
3. Cloth rags
4. Power source

## SAFETY

Remember, steam burns very easily.

Figure 1. Steam is dangerous.

INSTRUCTIONS

A. PREPARING THE STEAM CLEANER FOR USE

In preparing a steam cleaner for use, according to the manufacturer's service manual, you should:

1. Visually inspect machine for soundness of parts.
2. Attach water hose and power cord.
3. Replace drain plug if needed.
4. Check fuel and refill.
5. Turn on fuel and power source.
6. Start pump.
7. Uncoil steam hose.
8. Start burner when water runs out of nozzle.
9. Add soap.

Figure 2. Use a putty knife to remove heavy accumulations of grease and grime.

Courtesy of the American Association for Vocational Instructional Materials

INSTRUCTIONS

B. CLEANING THE TRACTOR

In cleaning the tractor with a steam cleaner the following procedure should be used:

1. Remove tractor hood, muffler, and air breather.
2. Cover exhaust and intake openings.
3. Apply degreaser to heavy grease and oil deposits.
4. Secure protective clothing, gloves, and safety face shield.
5. Hold end of nozzle 8 to 10 inches (20.32 to 25.40 cm) from tractor.
6. Move nozzle in back-and-forth motion parallel to tractor surface.
7. Avoid steaming of areas such as starter, generator, alternator, distributor, coil.
8. Continuously check functioning of steam cleaner.
9. Clean all areas of tractor (except those areas mentioned above). Use soap for the first application; finish with steam only.

INSTRUCTIONS

C. SHUTTING DOWN THE STEAM CLEANER

The following procedure should be used to shut down the steam cleaner:

1. Shut off burner.
2. Allow pump to run until water coming from nozzle is cool.
3. Shut off pump and water supply.
4. Disconnect water and power supply.
5. Drain steamer.

6. Clean up and put away steam cleaner and cleaning materials.

STUDENT SELF–CHECK
*DO NOT WRITE ON THIS PAGE!*
CLEANING THE TRACTOR

1. Why must the tractor be cleaned before disassembly?

2. When should the burner be started on the steam cleaner?

3. Which tractor parts should not be cleaned?

Compare your answers with the correct responses on this page. Review any incorrect answers before going on to the next Learning Activity.

**Figure 3. De-greasers are available in (a) small pressure-type cans, or (b) in bulk as a concentrate requiring dilution before being applied.**

**Courtesy of the American Association for Vocational Instructional Materials**

CORRECT RESPONSES

1. To avoid contaminating internal parts
2. After water runs out the nozzle
3. The starter, alternator, generator, distributor and coil

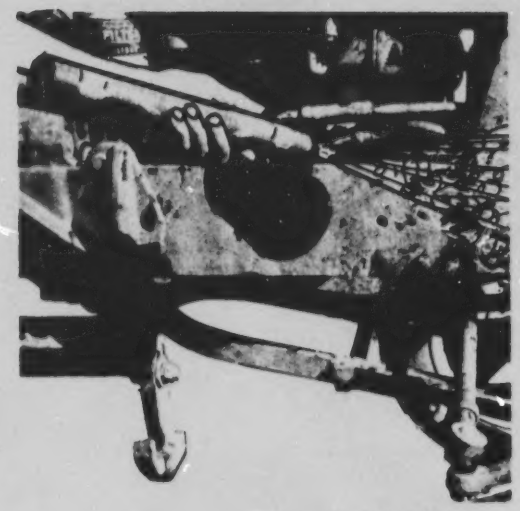


**Figure 4. Apply solvent on areas that need cleaning.**

**Courtesy of the American Association for Vocational Instructional Materials**

CHECK–OUT ACTIVITIES

The statements below explain the activities you must be able to complete in order to finish this learning activity package. As you go through each activity, your instructor will rate your performance using the Instructor's Final Checklist, CLEANING THE TRACTOR.

In the laboratory area, prepare the steam cleaner for use.

In a well ventilated area of the laboratory, clean a tractor with the steam cleaner.

Prepare and shut-down the steam cleaner.

DO NOT WRITE ON THIS PAGE

LAP TM–1

Student _____

Date _____

## CLEANING THE TRACTOR

### Instructor's Final Checklist

Check the student's performance in the following elements of cleaning the tractor.

Place an X in the appropriate box indicating not accomplished, partially accomplished, or fully accomplished. If, because of special circumstances, the item was impossible to complete, place an X in the "Not Applicable" box.

Performance Level: All items must receive a rating of FULLY ACCOMPLISHED (or Not Applicable). If any items are rated Not Accomplished or Partially Accomplished, the student and instructor will discuss this and decide which learning activities must be repeated.

| | Student Performance | | | |
|---|---|---|---|---|
| | Not Applicable | Not Accomplished | Partially Accomplished | Fully Accomplished |
| 1. To prepare the steam cleaner for use, the student: | | | | |
| a. attached the water hose and power cord | [ ] | [ ] | [ ] | [ ] |
| b. turned on the fuel and started the pump | [ ] | [ ] | [ ] | [ ] |
| c. started the burner when water water ran from nozzle | [ ] | [ ] | [ ] | [ ] |
| 2. The steam cleaner operated properly | [ ] | [ ] | [ ] | [ ] |
| 3. In cleaning a tractor with the steam cleaner, the student: | | | | |
| a. covered the exhaust and intake openings | [ ] | [ ] | [ ] | [ ] |
| b. applied degreaser to heavy grease and oil deposits | [ ] | [ ] | [ ] | [ ] |
| c. used protective clothing, gloves, and safety face shield | [ ] | [ ] | [ ] | [ ] |
| d. avoided steaming of areas such as starter, generator, alternator, distributor, and coil | [ ] | [ ] | [ ] | [ ] |
| e. continuously checked functioning of steam cleaner | [ ] | [ ] | [ ] | [ ] |
| 4. The cleaned tractor showed no signs of dirt, oil, loose rust, or grease | [ ] | [ ] | [ ] | [ ] |

DO NOT WRITE ON THIS PAGE

LAP TM–1

Student _____

Date _____

## CLEANING THE TRACTOR

### Instructor's Final Checklist

Check the student's performance in the following elements of cleaning the tractor. (Continued)

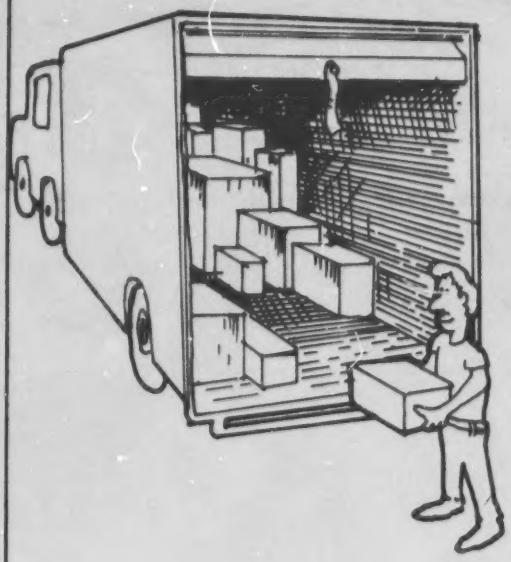
Place an X in the appropriate box indicating not accomplished, partially accomplished, or fully accomplished. If, because of special circumstances, the item was impossible to complete, place an X in the "Not Applicable" box.

Performance Level: All items must receive a rating of FULLY ACCOMPLISHED (or Not Applicable). If any items are rated Not Accomplished or Partially Accomplished, the student and instructor will discuss this and decide which learning activities must be repeated.

| | Student Performance | | | |
|---|---|---|---|---|
| | Not Applicable | Not Accomplished | Partially Accomplished | Fully Accomplished |
| 5. In shutting down the steam cleaner, the student: | | | | |
| a. shut off the burner | [ ] | [ ] | [ ] | [ ] |
| b. allowed the pump to run until water coming from the nozzle was cool | [ ] | [ ] | [ ] | [ ] |
| 6. The steam cleaner was drained, cleaned, and stored in the proper shop location | [ ] | [ ] | [ ] | [ ] |

# Learning Activity Package Number 2

Objective 5



## Receiving New Tractor Parts

## Tractor Mechanics

### INTRODUCTION

New tractor parts are often damaged during shipment. Replacing old parts with damaged new parts can cause more trouble and more expense than the original old worn parts. To avoid problems, you need to inspect parts for damage when they arrive. During such inspection you should also make sure that you have received the right parts and all of the parts you paid for. In this learning activity package you will learn the correct procedure for inspecting new tractor parts.

### DIRECTIONS

Read the objective below. If you believe you are already able to perform this task, read the Check-Out Activity on page 3 of this package. Then, either arrange with your instructor about doing the Check-Out Activity,

or

If you need to complete learning activities in order to be able to do the task, turn to p. 2 and go through the Learning Activities in the order given.

### OBJECTIVE

Given an unopened box of tractor parts, open the box and inspect contents for damage. All accepted parts should show no damage.

## LEARNING ACTIVITIES

1 READ *INSTRUCTIONS – INSPECTING NEW TRACTOR PARTS.*

(or) _____

2 CHECK YOUR KNOWLEDGE of receiving new tractor parts by completing *STUDENT SELF–CHECK – RECEIVING NEW TRACTOR PARTS.*

3 READ the original invoice to determine the parts that were ordered.

(or) _____

4 STUDY the manufacturer's service manual to visually recognize the parts listed on the original invoice.

(or) _____

5 INSPECT slightly damaged parts provided by the instructor to determine their damage.

6 ARRANGE with your instructor to complete this learning activity package by going through the CHECK-OUT ACTIVITIES listed on page 3.

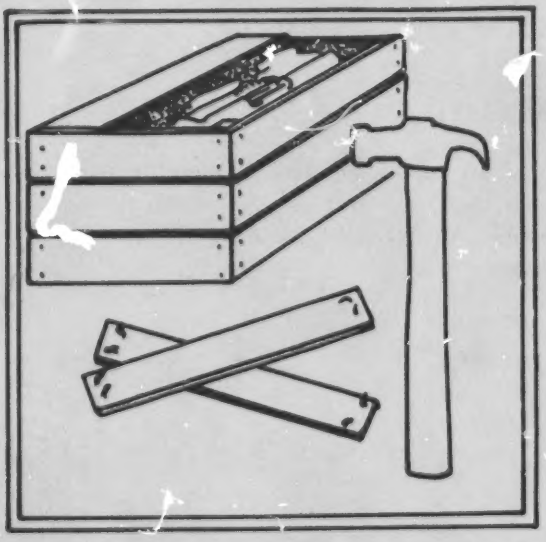


Figure 1. Watch for nails when uncrating.

Figure 2. Check unfamiliar parts with parts catalog.

## TOOLS AND EQUIPMENT NEEDED

1. Hammer
2. Pry Bar
3. Knife

## MATERIALS AND SUPPLIES NEEDED

1. Original invoice forms
2. Pencil

## SAFETY

1. Watch out for exposed nails or tacks which can cause serious puncture wounds.
2. Wear gloves to protect against cuts from banding wire.

## INSTRUCTIONS

### INSPECTING NEW TRACTOR PARTS

To insure that all new parts ordered are present and in sound condition:

1. Open package using tools that will not damage contents.

2. Remove and check packing list with original invoice.

3. Check that all parts listed on the packing slip are there.

4. Remove each part and inspect for damage that would prohibit its proper function. (See if the part is broken, dented, scratched, bent, etc.)

5. Prepare damaged parts to be returned to supplier.

6. Put usable parts in appropriate storage until needed.

Figure 3. Inspect each part for damage.

**STUDENT SELF–CHECK**
*DO NOT WRITE ON THIS PAGE!*
**RECEIVING NEW TRACTOR PARTS**

1. When inspecting a new shipment of parts, you should check for two things. Can you list them?

Compare your answers with the correct responses on this page. Review any incorrect answers before going on to the next Learning Activity.

**CORRECT RESPONSE**

1. a. All parts ordered are received.
   b. Parts received are not damaged.

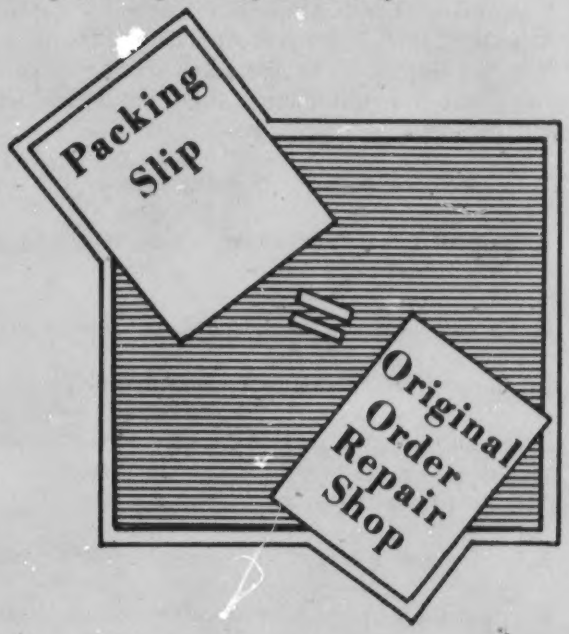



Figure 4. Check each part on the original Invoice and Packing Slip.

**CHECK–OUT ACTIVITIES**

The statement below explains the activity you must be able to complete in order to finish this learning activity package. As you go through the activity, your instructor will rate your performance using the Instructor's Final Checklist, RECEIVING NEW TRACTOR PARTS.

Open a box of tractor parts and visually inspect for damage to the contents. Accept all undamaged parts.

DO NOT WRITE ON THIS PAGE

LAP TM–2

Student _____

Date _____

## RECEIVING NEW TRACTOR PARTS

### Instructor's Final Checklist

Check the student's performance in the following elements of receiving new tractor parts.

Place an X in the appropriate box indicating not accomplished, partially accomplished, or fully accomplished. If, because of special circumstances, the item was impossible to complete, place an X in the "Not Applicable" box.

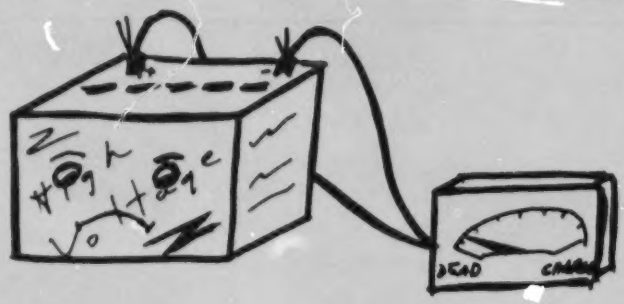
Performance Level: All items must receive a rating of FULLY ACCOMPLISHED (or Not Applicable). If any items are rated Not Accomplished or Partially Accomplished, the student and instructor will discuss this and decide which learning activities must be repeated.

| | Student Performance | | | |
|---|---|---|---|---|
| | Not Applicable | Not Accomplished | Partially Accomplished | Fully Accomplished |
| To inspect new parts for shipping damage, the student: | | | | |
| 1. opened package using tools that did not damage contents | [ ] | [ ] | [ ] | [ ] |
| 2. removed and checked packing list with original invoice | [ ] | [ ] | [ ] | [ ] |
| 3. noted any missing parts listed on the packing slip | [ ] | [ ] | [ ] | [ ] |
| 4. removed each part and inspected for damage (breakage, dents, scratches, bends, etc.) that would prohibit its proper function | [ ] | [ ] | [ ] | [ ] |
| 5. prepared damaged parts for return to supplier | [ ] | [ ] | [ ] | [ ] |
| 6. put usable parts in appropriate storage until needed | [ ] | [ ] | [ ] | [ ] |

# Learning Activity Package Number 3

Objectives 25-26-27-28

## Testing the Battery



## Tractor Mechanics

### INTRODUCTION

It is discouraging to attempt to start a tractor and find that the battery is so weak it will not turn the starter. This problem can be avoided if the battery is tested periodically (every 50 hours of use) for state of charge and load-bearing capacity. In this learning activity package you will learn how to test the battery voltage with a hydrometer and a voltmeter. You will also learn how to test the battery for load-bearing capacity.

### DIRECTIONS

Read the objectives below. If you believe you are already able to perform these tasks, read the Check-Out Activities on page 6 of this package. Then, either arrange with your instructor about doing the Check-Out Activities,

or

If you need to complete learning activities in order to be able to do the tasks, turn to page 2 and go through the Learning Activities in the order given.

### OBJECTIVES

1. Given a battery, hydrometer, and a specific-gravity chart, measure the specific gravity in each battery cell. The measurement for all cells should be exactly the same as the instructor's.

2. Given a battery and a voltmeter with regular or expanded scale divisions, measure the battery voltage. The measurement should be within one volt of the instructor's measurement.

3. Given a hydrometer, load-test machine, and voltmeter, run a load test on a

battery. The voltage should not drop below 4.5 volts on a 6-volt battery nor below 9.0 volts on a 12-volt battery. Recorded results should not vary from the instructor's.

4. Given a hydrometer and voltmeter, run a load test on a battery using the starting motor. The voltage should not drop below [illegible] volts on a 6-volt battery nor below 9.0 volts on a 12-volt battery. Recorded results should not vary more than .2 volt from the instructor's.

Figure 1. "Forty acres to plow and this thing won't start!"

## LEARNING ACTIVITIES

1 READ *Tractor Maintenance: Principles and Procedures* (AAVIM), pp. 7-14.

(or) _____

2 READ the manufacturer's instruction manuals on the voltmeter and the load-test machine for their proper use.

(or) _____

3 PREPARE a specific-gravity chart similar to the one on p. 14 of *Tractor Maintenance: Principles and Procedures.*

(or) _____

4 READ *INSTRUCTIONS – A. MEASURING THE SPECIFIC GRAVITY OF A BATTERY USING A HYDROMETER; B. MEASURING THE VOLTAGE OF A BATTERY USING THE VOLTMETER;* and *C. RUNNING A LOAD TEST ON A BATTERY.*

(or) _____

5 CHECK YOUR KNOWLEDGE of testing for specific gravity by taking *STUDENT SELF–CHECK – ADJUSTING SPECIFIC GRAVITY READINGS.*

6 PRACTICE checking a battery voltage with a hydrometer and a voltmeter and checking the load-bearing capacity of a battery with the starting motor and a load-test machine. Follow the procedure outlined in Learning Activity 4 and the manufacturer's service manual.

7 ARRANGE with your instructor to complete this learning activity package by going through the CHECK-OUT ACTIVITIES listed on page 6.

## TOOLS AND EQUIPMENT NEEDED

1. Hydrometer
2. Voltmeter
3. Load-Test Machine

## MATERIALS AND SUPPLIES NEEDED

1. Battery
2. Specific Gravity Chart
3. Starting Motor
4. Clean Water

## SAFETY

1. Always wear safety glasses when working around battery acid.

Figure 2. A battery that has been charging may have enough hydrogen gas present to cause an explosion or fire in the presence of a spark or flame.

## INSTRUCTIONS

### A. MEASURING THE SPECIFIC GRAVITY OF A BATTERY USING A HYDROMETER

In using a hydrometer to test a battery, follow this procedure:

1. Remove the battery caps.
2. If electrolyte level is too low, add water and operate tractor or charge battery for about four hours to mix water with electrolyte.
3. Holding the hydrometer vertically, insert the nozzle into a battery cell.

Figure 3. Take reading with eye at liquid level.

Courtesy of the American Association for Vocational Instructional Materials

4. Squeeze hydrometer bulb and release slowly to draw electrolyte into the cylinder. Hydrometer float should be free to move. Shake gently to free the float.
5. With float at eye level, read the scale.
6. Read the temperature of the electrolyte. Add .004 to reading for each 10° (5.5°C) above 80°F (26.7°C) and subtract .004 for each 10° (5.5°C) below 80°F (26.7°C).
7. Return electrolyte to cell by squeezing bulb.
8. Clean the hydrometer with clear water after each cell is tested.
9. Check other cells.

10. Interpret readings using a specific gravity chart found on page 14 of *Tractor Maintenance.*

11. Variation should not be more than .050 from highest to lowest cell readings. Otherwise the battery should be replaced.

12. Clean and store hydrometer.

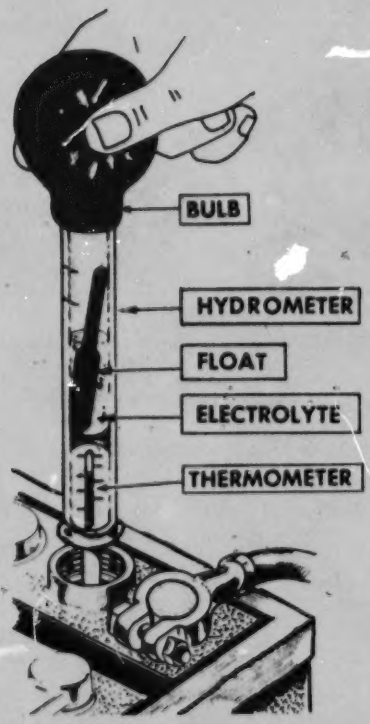



**Figure 4.** Draw electrolyte into hydrometer slowly.

Courtesy of the American Association for Vocational Instructional Materials

## INSTRUCTIONS

### B. MEASURING THE VOLTAGE OF A BATTERY USING THE VOLTMETER AND STARTER

To determine the voltage of a battery with a voltmeter, follow this procedure:

1. Connect the positive lead of the voltmeter to the positive post of the battery.

2. Connect the negative lead of the voltmeter to the negative post of the battery.

3. Disconnect the coil wire from the distributor cap so the engine will not run.

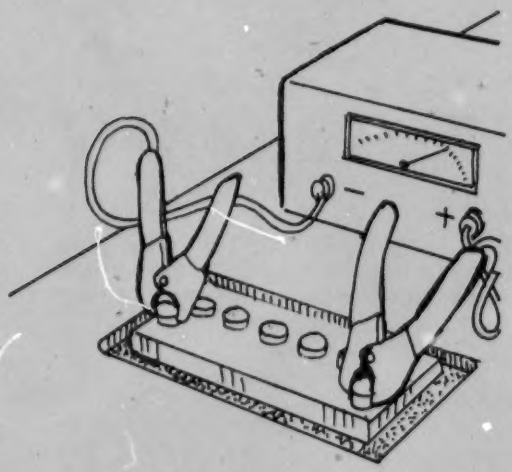



**Figure 5.** Testing the battery voltage with a voltmeter.

Courtesy of the American Association for Vocational Instructional Materials

4. Turn the starter switch just long enough to get voltmeter reading while the engine is turning over (about 30 seconds).

5. Disconnect positive and negative leads of voltmeter from the battery and replace coil wire.

6. Interpret voltmeter reading to determine if the battery needs recharging. Reading should not drop below 4.5 for a 6-volt battery or below 9 for a 12-volt battery.

(b)

Figure 6. An expanded-scale voltmeter—one that has .01 volt per scale division.

Courtesy of the American Association for Vocational Instructional Materials

## INSTRUCTIONS

### C. RUNNING A LOAD TEST ON A BATTERY

To load test with a load-testing machine, the following procedure should be used:

1. Check specific gravity.

2. Connect load-test machine according to the manufacturer's instructions.

3. Run load test with testing machine.

4. Record results.

5. Disconnect machine.

6. Interpret results using instructions with machine.

## STUDENT SELF–CHECK

*DO NOT WRITE ON THIS PAGE!*

### ADJUSTING SPECIFIC GRAVITY READINGS

Suppose that you have three batteries to be tested for operating conditions. If .004 is added for each 10°F above 80° and .004 is subtracted for each 10°F below 80°, calculate the true specific gravity reading for each cell as given. Show the amount you add or subtract to get the adjusted specific gravity. Use your specific-gravity chart for interpreting the adjusted specific gravity.

Compare your answers with the correct responses on the following page. Review any incorrect answers before going on to the next Learning Activity.

Battery No. 1 – 90°F [32.2°C]

Add or subtract

| Cell No. | Specific Gravity Reading | Average Adjusted Specific Gravity |
|---|---|---|
| 1 | 1.274 | _____ |
| 2 | 1.271 | _____ |
| 3 | 1.269 | _____ |
| 4 | 1.267 | _____ |
| 5 | 1.264 | _____ |
| 6 | 1.262 | _____ |

Probable condition of battery: (circle one)

Overcharged Undercharged
In Good Condition

Battery No. 2 – 120°F [49°C]

Add or subtract

| Cell No. | Specific Gravity Reading | Average Adjusted Specific Gravity |
|---|---|---|
| 1 | 1.163 | _____ |
| 2 | 1.160 | _____ |
| 3 | 1.158 | _____ |

Probable condition of battery: (circle one)

Overcharged Undercharged
In Good Condition

Battery No. 3 – 70°F [21.1°C]

Add or subtract

| Cell No. | Specific Gravity Reading | Average Adjusted Specific Gravity |
|---|---|---|
| 1 | 1.175 | _____ |
| 2 | 1.173 | _____ |
| 3 | 1.170 | _____ |
| 4 | 1.006 | _____ |
| 5 | 1.150 | _____ |
| 6 | 1.283 | _____ |

Probable condition of battery: (circle one)

Overcharged Undercharged
In Good Condition

## CORRECT RESPONSES

1. Add .004; Cell 1 – 1.278; Cell 2 – 1.275; Cell 3 – 1.273; Cell 4 – 1.271; Cell 5 – 1.268; Cell 6 – 1.266; Average – 1.2718; Battery is in good condition.

2. Add .017; Cell 1 – 1.179; Cell 2 – 1.176; Cell 3 – 1.174; Average – 1.143; Battery is undercharged.

3. Subtract .004; Cell 1 – 1.171; Cell 2 – 1.169; Cell 3 – 1.166; Cell 4 – 1.002; Cell 5 – 1.146; Cell 6 – 1.279; Average – 1.155; Battery condition is undercharged. (In this case, since there is more than 50 gravity points difference between the highest [cell 6] and the lowest [cell 4], the battery should be replaced.)

## CHECK–OUT ACTIVITIES

The statements below explain the activities you must be able to complete in order to finish this learning activity package. As you go through each activity, your instructor will rate your performance using the Instructor's Final Checklist, TESTING A BATTERY.

On the designated tractor:

Measure the specific gravity of the battery using a hydrometer.

Measure the voltage of the battery using a voltmeter.

Use a load-test machine to test the battery.

Run a load test on the battery using the starting motor.

DO NOT WRITE ON THIS PAGE

LAP TM–3

Student _____

Date _____

## TESTING A BATTERY

### Instructor's Final Checklist

Check the student's performance in the following elements of testing a battery.

Place an X in the appropriate box indicating not accomplished, partially accomplished, or fully accomplished. If, because of special circumstances, the item was impossible to complete, place an X in the "Not Applicable" box.

Performance Level: All items must receive a rating of FULLY ACCOMPLISHED (or Not Applicable). If any items are rated Not Accomplished or Partially Accomplished, the student and instructor will discuss this and decide which learning activities must be repeated.

| | Student Performance | | | |
|---|---|---|---|---|
| | Not Applicable | Not Accomplished | Partially Accomplished | Fully Accomplished |
| 1. In using a hydrometer to measure the specific gravity of a battery, the student: | | | | |
| a. shook hydrometer gently to keep the float from sticking to the sides | [ ] | [ ] | [ ] | [ ] |
| b. held the hydrometer and float at eye level and read the scale | [ ] | [ ] | [ ] | [ ] |
| c. took temperature reading of the electrolyte and made the hydrometer reading adjustment | [ ] | [ ] | [ ] | [ ] |
| d. interpreted the readings using a specific-gravity chart | [ ] | [ ] | [ ] | [ ] |
| 2. The interpreted readings for all cells were the same as the instructor's | [ ] | [ ] | [ ] | [ ] |
| 3. In measuring the voltage of a battery with a voltmeter, the student: | | | | |
| a. turned on the starter switch just long enough to get a voltmeter reading | [ ] | [ ] | [ ] | [ ] |
| b. secured a voltage reading | [ ] | [ ] | [ ] | [ ] |
| c. made the same interpretation as the instructor's | [ ] | [ ] | [ ] | [ ] |

DO NOT WRITE ON THIS PAGE

LAP TM–3

Student _____

Date _____

## TESTING A BATTERY (Cont'd)

### Instructor's Final Checklist

Check the student's performance in the following elements of testing a battery.

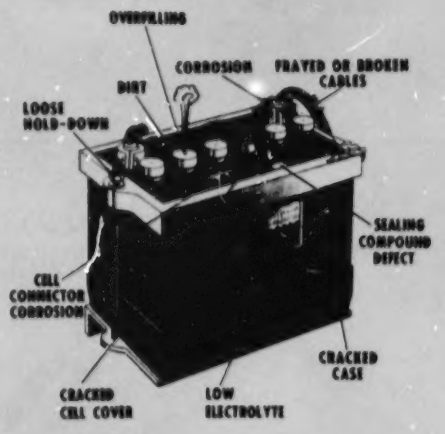
Place an X in the appropriate box indicating not accomplished, partially accomplished, or fully accomplished. If, because of special circumstances, the item was impossible to complete, place an X in the "Not Applicable" box.

Performance Level: All items must receive a rating of FULLY ACCOMPLISHED (or Not Applicable). If any items are rated Not Accomplished or Partially Accomplished, the student and instructor will discuss this and decide which learning activities must be repeated.

| | Student Performance | | | |
|---|---|---|---|---|
| | Not Applicable | Not Accomplished | Partially Accomplished | Fully Accomplished |
| 4. Using a load-testing machine to load-test a battery, the student: | | | | |
| a. checked the specific gravity of the battery | [ ] | [ ] | [ ] | [ ] |
| b. secured the same results as the instructor | [ ] | [ ] | [ ] | [ ] |
| 5. In load-testing a bettery using the starting motor, the student: | | | | |
| a. made sure the ignition was off | [ ] | [ ] | [ ] | [ ] |
| b. connected the voltmeter to the battery correctly | [ ] | [ ] | [ ] | [ ] |
| c. engaged the starter for at least 30 seconds | [ ] | [ ] | [ ] | [ ] |
| d. secured the same voltage reading as the instructor | [ ] | [ ] | [ ] | [ ] |

# Learning Activity Package Number 4

Objectives 24-29-30




Courtesy of John Deere and Company

# Servicing Battery Connections

# Tractor Mechanics

## INTRODUCTION

Many of the tractors that a mechanic will be expected to repair will have poor battery connections. If connections are loose, there is resistance to the flow of current which limits the voltage output of the battery. Corrosion on battery terminals also reduces voltage output and may totally prevent any battery function. A loose hold-down clamp allows the battery to move, which may result in damage to the battery. In this learning activity package you will learn how to properly clean, tighten, and coat battery connections.

## DIRECTIONS

Before you begin work on this package, be sure you have completed Learning Activity Package 3, "TESTING A BATTERY."

If you have completed this Learning Activity Package, read the objectives below. If you feel you are already able to perform these tasks, read the Check-Out Activities on page 4 of this package. Then, either arrange with your instructor about doing the Check-Out Activities,

or

If you need to complete learning activities in order to be able to do the tasks, find the Learning Activities inside this package and go through them in the order in which they are listed.

## OBJECTIVES

(1) Given a dirty battery, a box-end wrench, clamp puller, terminal-cleaning brush, sandpaper, baking soda, water, rags, and carrying strap, clean the battery terminals, cables, and battery box. The cleaned parts should show no visible signs of dirt, moisture, or acid.

(2) Given a battery with loose battery cables and battery hold-down clamps, battery pliers, and a socket wrench, tighten the cables and hold-down clamps. When pressure is applied, neither the cables nor the battery should move.

(3) Given a battery with clean terminals and a supply of light grease, treat the battery terminals. All areas that are subject to

corrosion should be coated with light grease.

## LEARNING ACTIVITIES

1 READ *Tractor Maintenance: Principles and Procedures,* pp. 63-65.

(or)_____

2 READ INSTRUCTIONS, SERVICING BATTERY CONNECTIONS.

(or)_____

3 CHECK YOUR KNOWLEDGE of cleaning batteries by taking Student Self-Check I, SERVICING BATTERY CONNECTIONS.

4 OBSERVE another student as he or she satisfactorily performs and is checked out on this package.

(or)_____

5 PRACTICE removing connections, cleaning clamps and terminals, and replacing connections on the designated tractor. Follow the procedure outlined in Instruction Sheet I and the manufacturer's service manual.

(or)_____

6 ARRANGE with your instructor to complete this learning activity package by going through the CHECK-OUT ACTIVITIES listed on page 4.

## TOOLS AND EQUIPMENT NEEDED

1. Wire Brush
2. Bristle Brush
3. Small Paint Brush
4. Battery Clamp Puller
5. Slot-Head Screwdriver
6. Box-End Wrenches

## MATERIALS AND SUPPLIES NEEDED

1. Baking Soda
2. Sandpaper
3. Container of Water
4. Light Grease

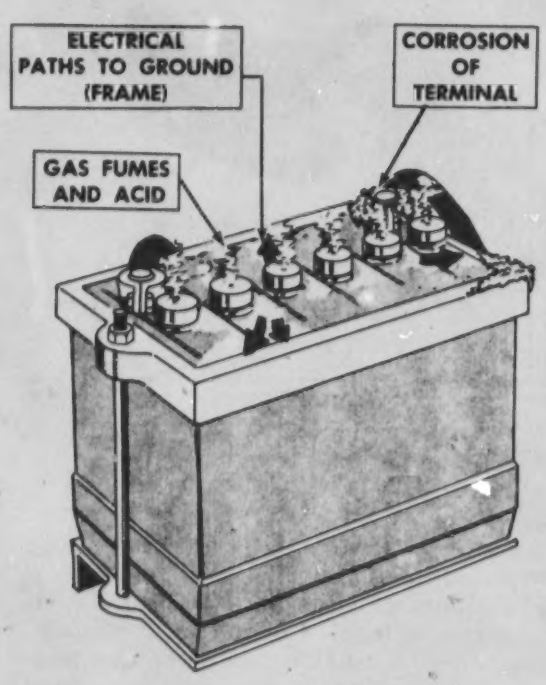



Figure 1. Gases that develop when battery is being charged by the generator or alternator carry acid as they escape from vents in battery caps. Acid settles on battery top and may accumulate enough to provide electrical paths to ground. This causes a battery to lose its charge and also causes corrosion of the cable terminals, carrier and the tractor frame.

Courtesy of the American Association for Vocational Instructional Materials

## SAFETY

Batteries emit flammable gases.

Batteries contain acid which can harm the skin or eyes and is poisonous if ingested.

## INSTRUCTIONS

## SERVICING BATTERY CONNECTIONS

In cleaning the battery and connections, the following procedure should be used:

1. Using box-end wrench, screwdriver, and clamp puller, disconnect the battery GROUND CABLE FIRST.
2. Loosen hold-down clamps.
3. Remove battery from tractor.
4. Clean battery terminals, cables, and battery box with brushes, sandpaper and baking soda. Flush with clean water.
5. Dry battery and box with clean rags.
6. Tighten hold-down clamps.
7. Connect battery. (NOTE: Install GROUND CABLE last.)

**Figure 2. To remove battery cable, loosen clamp bolt and carefully spread jaws on clamp.**

**Courtesy of the American Association for Vocational Instructional Materials**

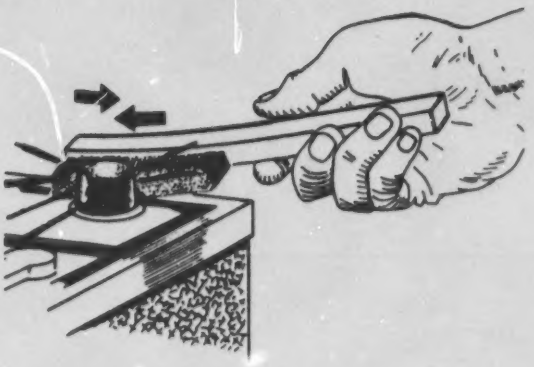


**Figure 3. Remove corrosion with a wire brush.**

**Courtesy of the American Association for Vocational Instructional Materials**

It is important that the cable and hold-down clamp be tight at all times. To insure tightness, follow this procedure:

1. Tighten battery cables.
2. Tighten battery hold-down clamps.
3. Test for tightness by applying moderate pressure to the cables and battery.
4. Retighten loose connections.

To reduce damage from corrosion, the exposed metal parts of the battery should be coated with a light grease. The following procedure should be used:

1. Apply a thin layer of light grease, such as petroleum jelly, to the posts and cable clamp connections. (Do not coat area between post and clamp where electrical contact is made. Do not use grease with a metallic additive.)
2. Wipe off excess grease with a clean rag.
3. Dispose of greasy rags.

**STUDENT SELF-CHECK**
*DO NOT WRITE ON THIS PAGE!*
**SERVICING BATTERY CONNECTIONS**

Answer the following:

1. To avoid damage to the battery, you should always use a _____to remove the battery cable from the battery.

2. What solution should be used to clean a battery?

3. Why avoid getting solution into the battery?

4. Apply a coating of _____or _____to the battery posts and cable clamps to protect against further corrosion.

5. What causes corrosion of the battery terminals?

6. Can a battery lose its charge as a result of accumulated dust and dirt on the surface of the battery? (Check One) Yes___ No___ Why?

7. Why is it important to remove the ground cable first and install it last?

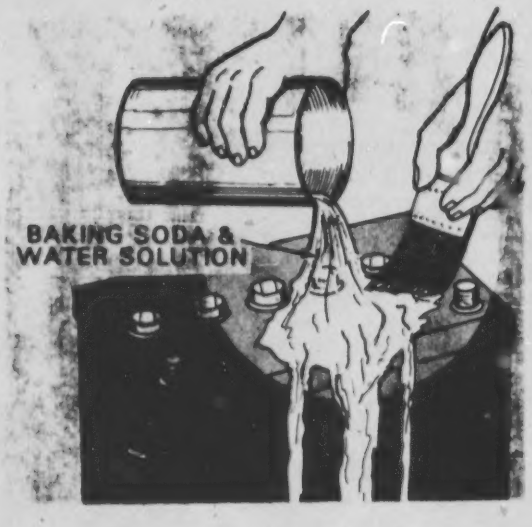



**Figure 4. Baking soda-and-water solution reacts with acid and neutralizes it.**

Courtesy of the American Association for Vocational Instructional Materials

Compare your answers with the correct responses at the bottom of this page. Review any incorrect answers before going on to the next learning activity.

**CHECK-OUT ACTIVITIES**

The statements below explain the activities you must be able to complete in order to finish this module. As you go through each activity, your instructor will rate your performance using the Instructor's Final Checklist, SERVICING BATTERY CONNECTIONS.

Clean the battery terminals, cables, and battery box on the designated tractor battery.

Tighten battery cables and battery hold-down clamps on the designated tractor.

Treat the battery terminals on the designated tractor to prevent corrosion.

**CORRECT RESPONSES**

1. Battery clamp puller
2. Two tablespoons of baking soda to a pint of water
3. Contaminates electrolyte, which will cause the battery to remain discharged
4. Grease, petroleum jelly
5. Acid and moisture
6. Yes; retains moisture which causes shorts between terminals.
7. This decreases the chance of creating a short circuit with the wrench.

DO NOT WRITE ON THIS PAGE

LAP TM–4

Student _____

Date _____

## SERVICING BATTERY CONNECTIONS

### Instructor's Final Checklist

Check the student's performance in the following elements of servicing battery connections.

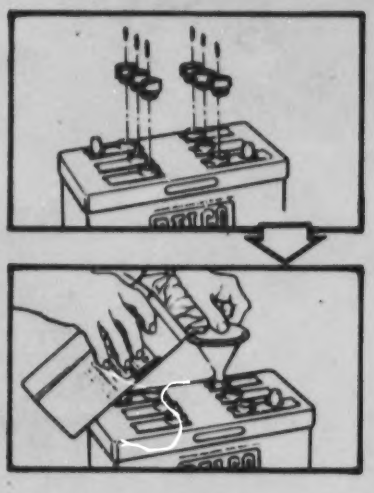
Place an X in the appropriate box indicating not accomplished, partially accomplished, or fully accomplished. If, because of special circumstances, the item was impossible to complete, place an X in the "Not Applicable" box.

Performance Level: All items must receive a rating of FULLY ACCOMPLISHED (or Not Applicable). If any items are rated Not Accomplished or Partially Accomplished, the student and instructor will discuss this and decide which learning activities must be repeated.

| | Student Performance | | | |
|---|---|---|---|---|
| | Not Applicable | Not Accomplished | Partially Accomplished | Fully Accomplished |
| 1. In cleaning the battery terminals, cables and battery box, the student: | | | | |
| a. disconnected the ground cable first | [ ] | [ ] | [ ] | [ ] |
| b. removed the battery from the tractor | [ ] | [ ] | [ ] | [ ] |
| c. cleaned the designated battery terminals, cables, and box so that there was no visible dirt, moisture, or acid | [ ] | [ ] | [ ] | [ ] |
| d. reconnected the battery correctly, ground cable last | [ ] | [ ] | [ ] | [ ] |
| 2. The student tightened the battery cables and hold-down clamps so that when pressure was applied, no movements of the battery or cables occurred | [ ] | [ ] | [ ] | [ ] |
| 3. In treating the battery terminals, the student: | | | | |
| a. coated all areas subject to corrosion with a light grease | [ ] | [ ] | [ ] | [ ] |
| b. avoided coating areas between post and clamp where electrical contact was made | [ ] | [ ] | [ ] | [ ] |
| c. wiped off excess grease | [ ] | [ ] | [ ] | [ ] |
| d. disposed of greasy rags safely | [ ] | [ ] | [ ] | [ ] |

# Learning Activity Package Number 5

Objective 22



Courtesy of John Deere and Company

## Activating a Battery

## Tractor Mechanics

### INTRODUCTION

A dry-charged battery is charged at the factory, but no electrolyte is added. This allows the battery to hold its charge for an indefinite period of time. If used without the electrolyte, the battery would lose its charge quite rapidly, causing extensive damage to the plates of the battery. Therefore, before a battery is used it must be activated. In this learning activity package you will learn how to activate a dry-charged battery.

### DIRECTIONS

Before you start to work on this learning activity package, be sure you have completed learning activity package 3, "Testing a Battery," and learning activity package 4, "Servicing Battery Connections."

If you have completed these Learning Activity Packages, read the objective below. If you feel you are already able to perform this task, read the Check-Out Activity on page 4 of this package. Then, either arrange with your instructor about doing the Check-Out Activity,

or

If you need to complete learning activities in order to be able to do the task, turn to page 2 and go through the Learning Activities in the order given.

### OBJECTIVE

Given a dry-charged battery, electrolyte, the manufacturer's service manual, protective equipment, battery syringe or manufacturer's dispenser, and a battery charger, activate the battery. The electrolyte should be 3/8 inch (.95 cm) above the plates. The reading on the voltmeter should be within one volt of the measurement obtained by the instructor.

## LEARNING ACTIVITIES

1 READ *Fundamentals of Service: Electrical Systems* (Deere & Company), pp. 3-6.

(or) _____

2 PREPARE a one-page report on the differences between a dry-charged battery and a wet-charged battery. Discuss the report with your instructor.

(or) _____

3 READ *INSTRUCTIONS – ACTIVATING A BATTERY.*

(or) _____

4 STUDY the cut-away battery provided by the instructor.

(or) _____

5 PRACTICE activating a dry-charged battery. Follow the procedure outlined in Learning Activity 3 and in the manufacturer's service manual.

6 ARRANGE with your instructor to complete this learning activity package by going through the CHECK-OUT ACTIVITIES listed on page 4.

## TOOLS AND EQUIPMENT NEEDED

1. Battery Syringe or Manufacturer's Dispenser
2. Battery Charger
3. Protective Equipment
4. Voltmeter

## MATERIALS AND SUPPLIES NEEDED

1. Electrolyte
2. Dry-Charged Battery

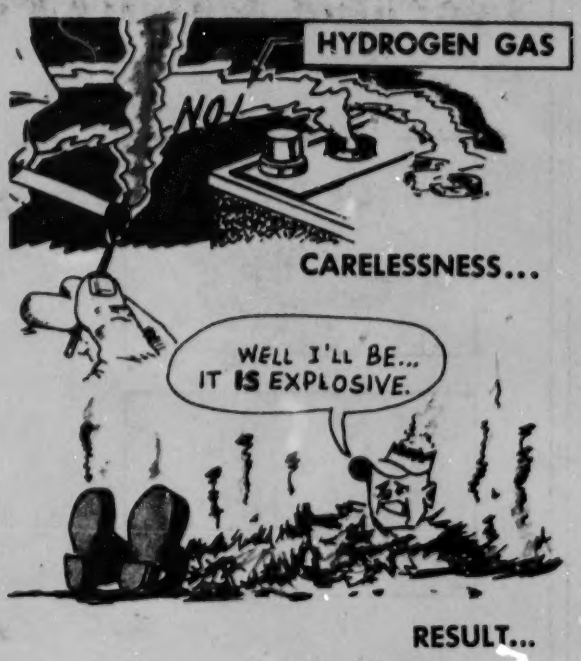



**Figure 1. A battery that has been charging may have enough hydrogen gas present to cause an explosion or fire in the presence of a spark or flame.**

**Courtesy of the American Association for Vocational Instructional Materials**

## SAFETY

1. Wear eye protection when working with electrolyte (acid).
2. Avoid flames or sparks. Hydrogen gas, which is highly explosive, is formed during charging.

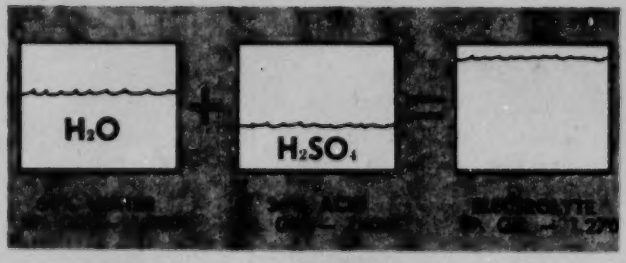



**Figure 2. Battery electrolyte consists of a solution of water ($H_2O$) an sulfuric acid ($H_2So_4$).**

**Courtesy of the American Association for Vocational Instructional Materials**

## INSTRUCTIONS

## ACTIVATING A BATTERY

In activating a battery, the following procedure should be used:

1. Remove battery from box.

2. Remove caps from battery cells.

3. Fill the battery with electrolyte, using a battery syringe. Fill to within 3/8 inches (approximately 9½ mm) above plates or as indicated by manufacturer.

4. Connect the battery charger and set for trickle (or low) charge. Plug in charger and check to make certain that positive lead is on positive terminal and that negative lead is on negative terminal. (Note: If terminals are not marked, the larger one is positive and the smaller is negative.)

5. Set voltage on the battery charger equal to that of the battery; i.e., a 6-volt battery is set at 6 volts; a 12-volt battery at 12 volts, etc.

6. Charge the battery at slow charge for at least 4 hours – preferably overnight. Charge in a well-ventilated area.

7. Clean and replace battery caps. (CAUTION: Make sure vent holes are clear.)

8. Measure battery voltage with a voltmeter.

## STUDENT SELF–CHECK

*DO NOT WRITE ON THIS PAGE!*

## ACTIVATING A BATTERY

1. A dry-charged battery is charged:

   (a) in the field
   (b) at the factory.

2. A dry-charged battery is activated:

   (a) in the field or warehouse
   (b) at the factory.

3. One disadvantage of using a dry-charged battery is:

   (a) will not hold a charge when properly stored for more than a couple of weeks
   (b) acids must be handled and it is difficult to check the quality of the battery before shipment from the factory.

4. After the battery has been in service and the electrolyte level gets low, acid should be added until the electrolyte level reaches the proper level. (True or False)

Compare your answers with the correct responses on the following page. Review any incorrect answers before going on to the next Learning Activity.

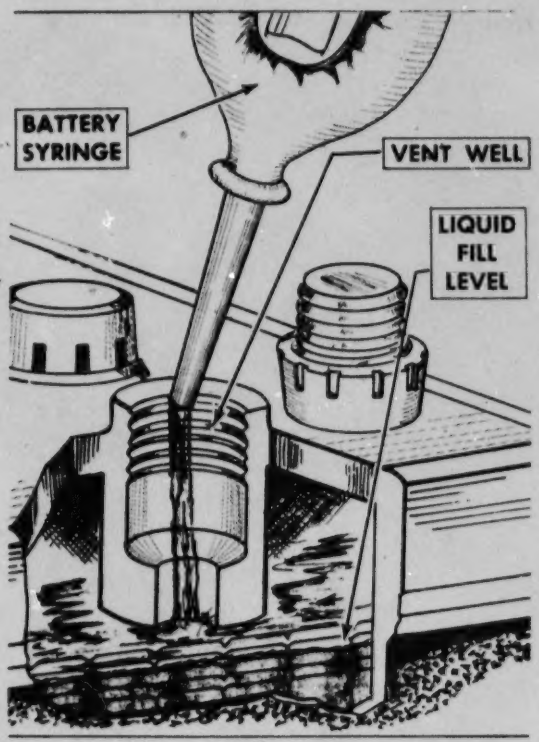



**Figure 3. Add water until electrolyte reaches bottom of extended vent well or until liquid level is about 3/8 inch above plates.**

Courtesy of the American Association for Vocational Instructional Materials

## CORRECT RESPONSES

1. b
2. a
3. b
4. False – Acid should NEVER be added after a battery has been in service.

## CHECK–OUT ACTIVITIES

The statement below explains the activity you must be able to complete in order to finish this learning activity package. As you go through the activity, your instructor will rate your performance using the Instructor's Final Checklist, ACTIVATING A BATTERY.

Activate a dry-charged battery in the shop area.

DO NOT WRITE ON THIS PAGE

LAP TM–5

Student _____

Date _____

## ACTIVATING A BATTERY

### Instructor's Final Checklist

Check the student's performance in the following elements of activating a battery.

Place an X in the appropriate box indicating not accomplished, partially accomplished, or fully accomplished. If, because of special circumstances, the item was impossible to complete, place an X in the "Not Applicable" box.

Performance Level: All items must receive a rating of FULLY ACCOMPLISHED (or Not Applicable). If any items are rated Not Accomplished or Partially Accomplished, the student and instructor will discuss this and decide which learning activities must be repeated.

| | | Student Performance | | | |
|---|---|---|---|---|---|
| | | Not Applicable | Not Accomplished | Partially Accomplished | Fully Accomplished |
| To activate a dry-charged battery, the student: | | | | | |
| 1. | removed caps from the battery cells | [ ] | [ ] | [ ] | [ ] |
| 2. | filled the battery cells with electrolyte using a battery syringe | [ ] | [ ] | [ ] | [ ] |
| 3. | slow-charged the battery overnight in a well-ventilated area | [ ] | [ ] | [ ] | [ ] |
| 4. | cleaned and replaced the battery caps making sure vent holes were clear | [ ] | [ ] | [ ] | [ ] |
| 5. | measured the battery voltage with a voltmeter | [ ] | [ ] | [ ] | [ ] |
| 6. | had a reading on the voltmeter that was within one volt of the instructor's reading | [ ] | [ ] | [ ] | [ ] |

# Learning Activity Package Number 6

Objective 23

Courtesy of the American Association for Vocational Instructional Materials

## Charging a Battery

## Tractor Mechanics

### INTRODUCTION

A wet-charged battery is fully charged at the factory and filled with electrolyte. During storage or non-use the chemicals undergo a slow reaction called self-discharge. Sulfation, the formation of a whitish scale of lead sulfate on the surfaces of the battery plates, begins to take place as a battery becomes discharged. If such sulfation is allowed to continue, the battery becomes difficult to recharge. To avoid the expense of a new battery, it is best to keep the battery at full charge. In this learning activity package you will learn how to charge a wet-charged battery.

### DIRECTIONS

Before you start to work on this learning activity package, be sure you have completed learning activity package 3, "Testing a Battery," learning activity package 4, "Servicing Battery Connections," and learning activity package 5, "Activating a Battery."

If you have completed these Learning Activity Packages, read the objective below. If you feel you are already able to perform this task, read the Check-Out Activity on page 4 of this package. Then, either arrange with your instructor about doing the Check-Out Activity,

or

If you need to complete learning activities in order to be able to do the task, turn to page 2 and go through the Learning Activities in the order given.

### OBJECTIVE

Given a wet-charged battery, a battery charger, and a hydrometer, charge the battery. Electrolyte level should be 3/8 inch (.95 cm) above the plate. The hydrometer reading should be exactly the same as the instructor's reading on each cell.

## TOOLS AND EQUIPMENT NEEDED

1. Battery Charger
2. Hydrometer

## MATERIALS AND SUPPLIES NEEDED

1. Wet-Charged Battery
2. Soda Solution
3. Rags

## SAFETY

1. Hydrogen gas, which is highly explosive, is formed during charging. Avoid flames and sparks.
2. Avoid any contact with electrolyte. Wear eye protection.

**Figure 1.** A battery that has been charging may have enough hydrogen gas present to cause an explosion or fire in the presence of a spark or flame.

Courtesy of the American Association for Vocational Instructional Materials

## LEARNING ACTIVITIES

1 READ *Fundamentals of Service: Electrical Systems* (Deere & Company), pp. 3-7 to 3-8 and 3-14 to 3-16.

(or) _____

2 STUDY the summary of charging batteries on pp. 3-15 and 3-16 in *Fundamentals of Service: Electrical Systems.*

(or) _____

3 CHECK YOUR KNOWLEDGE of charging batteries by taking *STUDENT SELF-CHECK – CHARGING A BATTERY.*

4 READ *INSTRUCTIONS – CHARGING A BATTERY.*

(or) _____

5 EXAMINE the sulfated plates provided by the instructor.

(or) _____

6 READ the section on the battery charger in the manufacturer's service manual for the designated tractor.

(or) _____

7 PRACTICE connecting the battery charger in preparation for charging a battery. Follow the procedure outlined in Learning Activity 4 and the manufacturer's service manual.

8 ARRANGE with your instructor to complete this learning activity package by going through the CHECK-OUT ACTIVITIES listed on page 4.

## INSTRUCTIONS

## CHARGING A BATTERY

In charging a battery, the following procedure should be used:

1. Remove all caps.
2. Check electrolyte level.
3. Add distilled water to cells which appear low.
4. Check specific gravity.
5. To eliminate excessive boiling, charge battery at moderate rate for a minimum of four hours. Electrolyte should never heat above 120°F (49°C).
6. Check battery periodically to determine degree of charge.
7. Turn off and remove charger when battery reaches full charge. (CAUTION: Hydrogen gas, which is highly explosive, is formed during charging. Avoid flames and sparks.)
8. Replace cell caps.
9. Clean off any electrolyte which might have boiled out on top of battery. (CAUTION: Avoid any contact with electrolyte.)

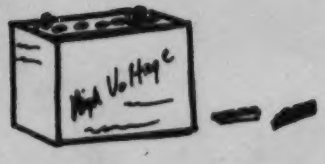


Figure 3. Remove caps before charging

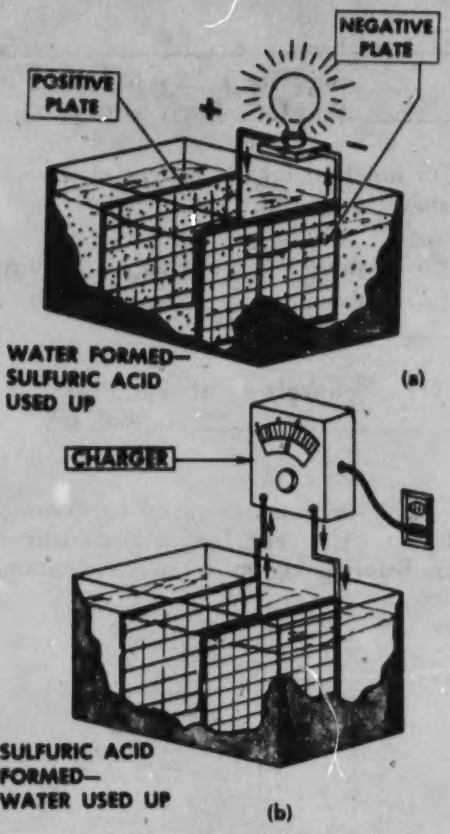



Figure 2. How a battery works. (a) While a battery is supplying power, a portion of the sulfuric acid is taken from the electrolyte; water is returned as a result of the chemical reaction. (b) As the battery is re-charged, the opposite happens- a portion of the water is taken from the electrolyte and sulfuric acid is returned.

Courtesy of the American Association for Vocational Instructional Materials

## STUDENT SELF–CHECK

*DO NOT WRITE ON THIS PAGE!*

## CHARGING A BATTERY

Answer the following:

1. Batteries are charged by _____ their flow of current using an outside power source.
2. There are two ways to recharge a battery: _____ and _____.
3. If a battery is sulfated, use a _____ _____ but reduce the charging rate.
4. If the battery is badly sulfated and will not accept a fast charge, use the _____ _____ method.

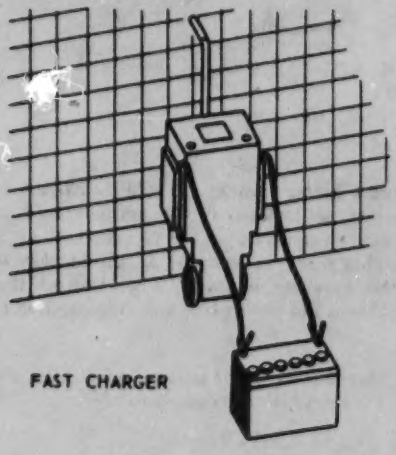
5. If fast charging is used, never exceed _____ amps for a 12-volt battery or _____ amps for a 6-volt battery.

6. Do not heat up the battery electrolyte above _____ °F.

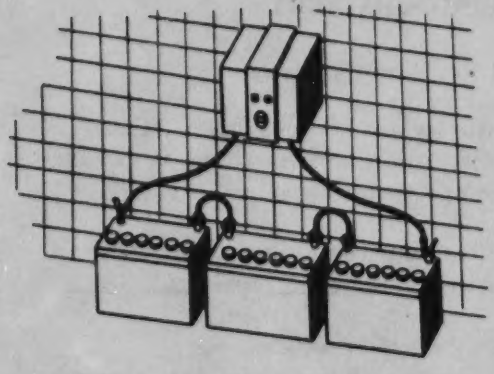
7. To assure a fully charged battery, follow the _____ _____ with a _____ _____.

8. After charging, always check the _____ _____ in each cell.

Compare your answers with the correct responses on this page. Review any incorrect answers before going on to the next Learning Activity.



FAST CHARGER



SLOW CHARGER

**Figure 4. Battery Charging**

Courtesy of the American Association for Vocational Instructional Materials

## CORRECT RESPONSES

1. Reversing
2. Fast charging, slow charging
3. Fast charge
4. Slow charging
5. 40, 70
6. 120 (49°C)
7. Fast charge, slow charge
8. Electrolyte level

## CHECK–OUT ACTIVITIES

The statement below explains the activity you must be able to complete in order to finish this learning activity package. As you go through the activity, your instructor will rate your performance using the Instructor's Final Checklist, CHARGING A BATTERY.

In the shop area, charge a wet cell battery.

DO NOT WRITE ON THIS PAGE

LAP TM–6

Student _____

Date _____

## CHARGING A BATTERY

### Instructor's Final Checklist

Check the student's performance in the following elements of charging a battery.

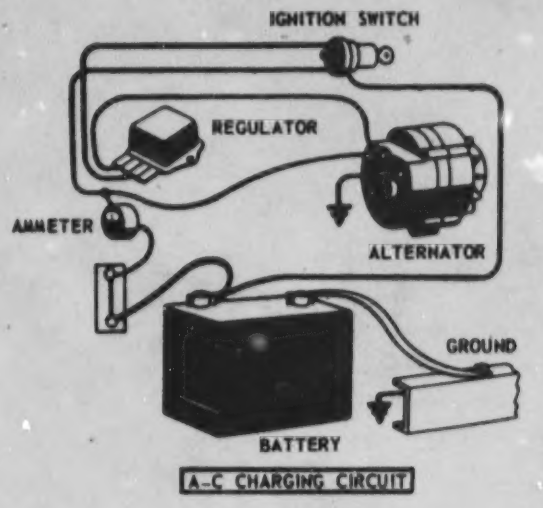
Place an X in the appropriate box indicating not accomplished, partially accomplished, or fully accomplished. If, because of special circumstances, the item was impossible to complete, place an X in the "Not Applicable" box.

Performance Level: All items must receive a rating of FULLY ACCOMPLISHED (or Not Applicable). If any items are rated Not Accomplished or Partially Accomplished, the student and instructor will discuss this and decide which learning activities must be repeated.

| | | Student Performance | | | |
|---|---|---|---|---|---|
| | | Not Applicable | Not Accomplished | Partially Accomplished | Fully Accomplished |
| 1. | In charging a battery, the student: | | | | |
| | a. removed caps and added distilled water | [ ] | [ ] | [ ] | [ ] |
| | b. checked specific gravity | [ ] | [ ] | [ ] | [ ] |
| | c. charged battery at moderate rate for 4–6 hours | [ ] | [ ] | [ ] | [ ] |
| | d. checked battery periodically to determine degrees of charge | [ ] | [ ] | [ ] | [ ] |
| | e. turned off and removed charger when battery reached full charge | [ ] | [ ] | [ ] | [ ] |
| | f. used caution in handling the battery and electrolyte | [ ] | [ ] | [ ] | [ ] |
| | g. cleaned electrolyte off the top of the battery | [ ] | [ ] | [ ] | [ ] |
| 2. | The student's specific gravity reading was the same as the instructor's | [ ] | [ ] | [ ] | [ ] |
| 3. | The electrolyte level was 3/8" above the plates | [ ] | [ ] | [ ] | [ ] |

# Learning Activity Package Number 7

Objectives 53–55–63




A-C CHARGING CIRCUIT

Courtesy of John Deere and Company

## Testing the Charging Circuit

## Tractor Mechanics

### INTRODUCTION

The battery used on most tractors provides energy to start the engine. The charging circuit, which consists of the battery, a generator and a voltage regulator, keeps the battery charged. In this learning activity package you will learn how each part of the charging circuit works and how to service and repair the circuit.

### DIRECTIONS

Read the objectives below. If you believe you are already able to perform these tasks, read the Check-Out Activities on page 7 of this package. Then, either arrange with your instructor about doing the Check-Out Activities,

or

If you need to complete learning activities in order to be able to do these tasks, turn to p. 2 and go through the Learning Activities in the order given.

### OBJECTIVES

1. Given a voltmeter, ammeter, carbon-pile resistor, and the necessary tools, test the charging circuit. The readings on the test equipment should be 100% accurate when compared to those of the instructor.

2. Given the ammeter, carbon-pile resistor, voltmeter, switch and necessary tools, test the generator on the bench to determine output. The voltmeter and ammeter readings should be 100% accurate when compared to those of the instructor.

3. Given proper test lamp, growler, combination test unit, necessary tools and equipment, check the armature and field. The readings on the test equipment should be 100% accurate when compared to those of the instructor.

## LEARNING ACTIVITIES

1 READ *The Tractor Electrical System* (AAVIM), pp. 35-38.

(or)_____

2 VIEW slide series, "Electrical Systems," slides 109-117, (Deere)

(or)_____

3 CHECK YOUR KNOWLEDGE of the charging circuit by taking the STUDENT SELF–CHECK, UNDERSTANDING THE CHARGING CIRCUIT.

4 READ the section on the charging circuit in the manufacturer's service manual for the designated tractor.

(or)_____

5 PRACTICE testing the charging circuit, checking the armature and field, and testing the generator on the bench. Follow the procedure outlined in INSTRUCTIONS, TESTING THE CHARGING CIRCUIT, and the directions in the manufacturer's service manual.

6 ARRANGE with your instructor to complete this learning activity package by going through the CHECK-OUT ACTIVITIES listed on page 7.

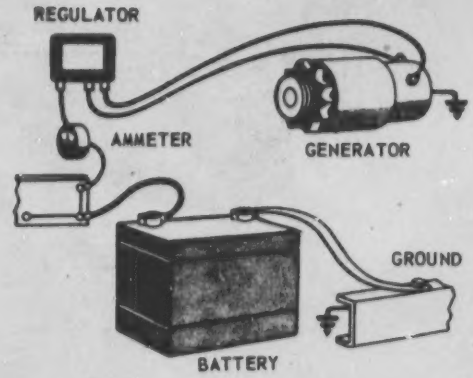



Figure 2. D-C Charging Circuit

Courtesy of John Deere and Company

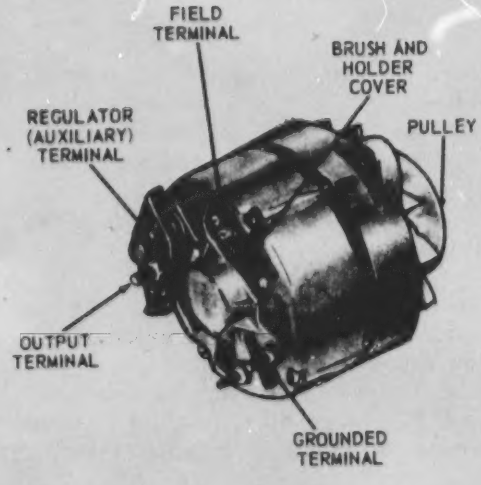



Figure 1. Complete Alternator

Courtesy of John Deere and Company

## TOOLS AND EQUIPMENT NEEDED

1. Voltmeter
2. Carbon-pile Resistor
3. Ammeter
4. Mechanic's Tool Set
5. Test Lamp
6. Growler
7. Combination Test Unit

## SAFETY

1. No special safety precautions

## INSTRUCTIONS

### TESTING THE CHARGING CIRCUIT

In testing the charging circuit, the following procedure should be used:

1. Refer to the manufacturer's service manual for specific instructions and procedures.
2. Set up test circuit.
3. Connect voltmeter to the alternator gound and output terminal. Voltmeter should be accurate within 0.1 volts.
4. Start engine and insert a load of about 10 amp. (Use lights, motors, carbon-pile resistors, etc.)
5. Operate the circuit for about 15 minutes to stabilize the temperature of the regulators. Measure and record the temperature by holding the thermometer about one inch from the regulator case.
6. Compare the voltmeter reading with the voltage specifications listed in the manufacturer's service manual. Adjust the reading for the temperature recorded in Step 5.

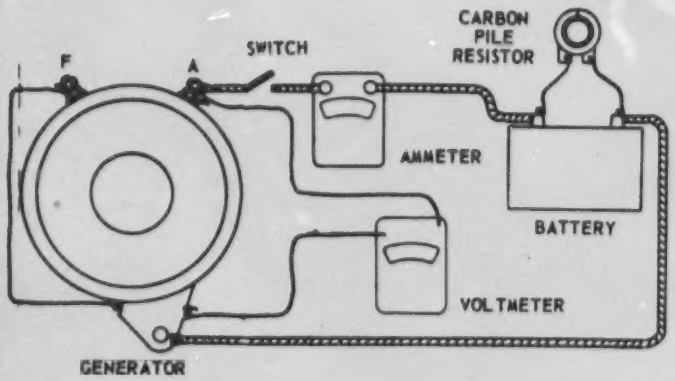



Figure 3. Testing the Generator Output

Courtesy of John Deere and Company

In testing the generator, the following procedure should be used:

1. Consult the manufacturer's service manual for service and repair specifications.
2. Connect an ammeter and switch, in series with a battery, to the generator output terminal.
3. Connect a voltmeter from the generator output to ground.
4. Connect a carbon pile resistor across the battery.
5. Connect a jumper lead to the generator field terminal.
6. Operate the generator to obtain battery voltage and close the switch.
7. Speed up the generator to its rated value, adjust the carbon pile to obtain the specified voltage, and compare the current output with the generator specifications.
8. If the generator output is below par, check for additional malfunctions.

In testing the armature and field, the following procedure should be used:

1. Visually inspect the armature for an open circuit. The trailing edge of the bar attached to the open loop will usually be badly burned.
2. Test for an open circuit using combination test unit and growler.
   a. Place test prods of the unit on two adjacent commutator bars. Rotate the armature to get the highest meter reading and record the reading.
   b. Turn the armature slightly and check the two other bars. If one reading is lower than the others, that circuit is open.
3. Perform additional tests for shorted armature and grounded armature if needed.

4. Test for an open field circuit by using a test lamp. Touch the prods of the lamp to generator terminals. If the lamp does not light, the field circuit is open.

5. Test for grounded field circuit or shorted field circuit.

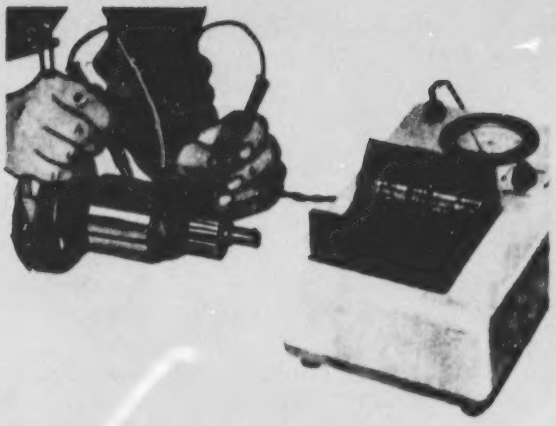


Figure 4. Testing for Grounded Armature

Courtesy of John Deere and Company

STUDENT SELF-CHECK
*DO NOT WRITE ON THIS PAGE!*
UNDERSTANDING THE CHARGING CIRCUIT

1. When the engine is running, the _____ supplies the electrical energy needed to operate the machine.

2. When starting the engine, the _____ supplied the electrical energy needed.

3. The faster the generator is turned by the engine, the higher the voltage produced. (True, False)

4. The purpose of a field pole is to strengthen the magnetic field, (True, False)

5. The brushes carry current (to, from) the generator.

6. A third brush-type generator is used where a high current output is not required. (True, False)

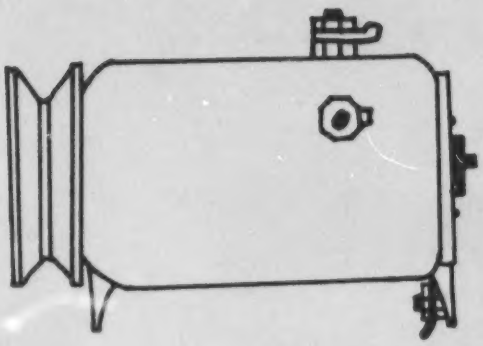
7. The _____ of a generator determines the direction of current flow between the generator and the external circuit.

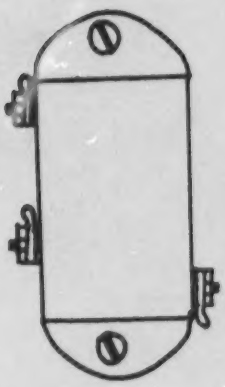
8. The generator is prevented from producing excess voltage by _____.

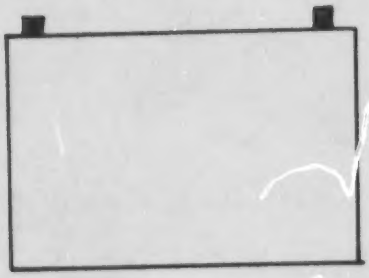
9. The generator produces _____ current, while the alternator produces _____ current.

10. The diode is in the circuit to _____.

11. Draw in the wiring on the diagram on the following page.



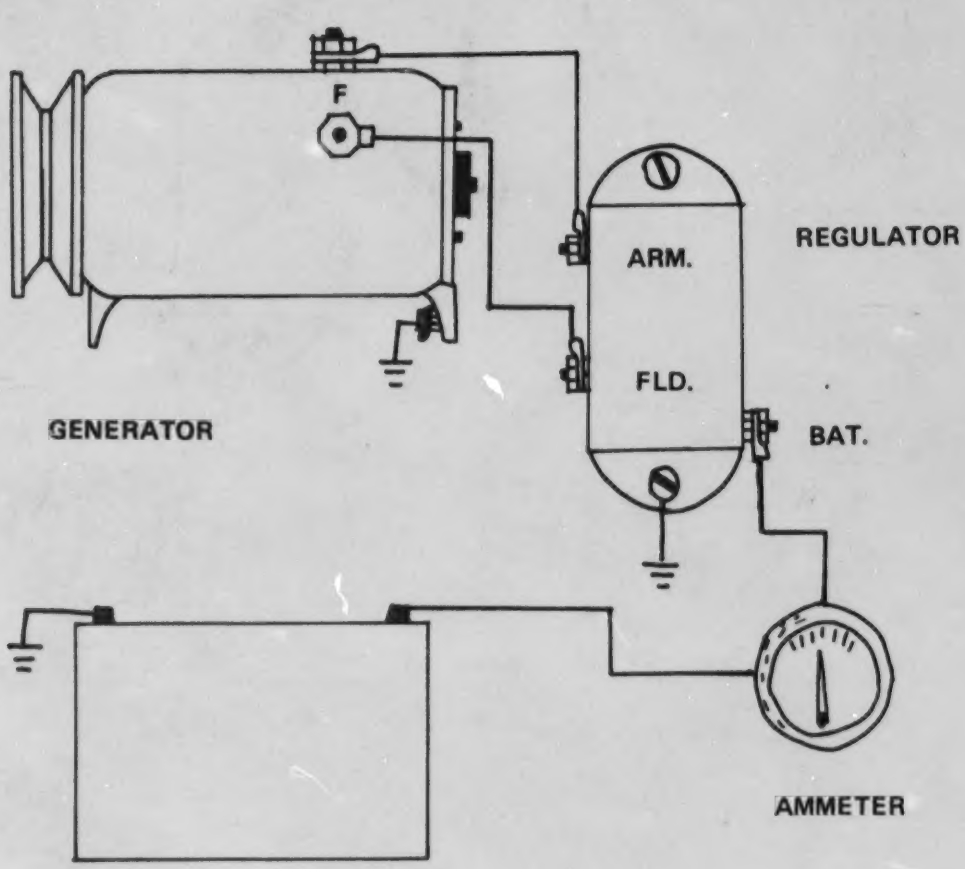




Compare your answers with the correct responses on the following page. Review any incorrect answers before going on to the next Learning Activity.

**CORRECT RESPONSES**

1. generator
2. battery
3. true
4. true
5. from
6. true
7. polarization
8. voltage regulator
9. D.C., A.C.
10. Change A.C. current to D.C. current.
11. See the illustration below:



## CHECK-OUT ACTIVITIES

The statements below explain the activities you must be able to complete in order to finish this learning activity package. As you go through each activity, your instructor will rate your performance using the Instructor's Final Checklist, TESTING THE CHARGING CIRCUIT.

On the designated tractor:

Test the charging circuit.

Bench-test the generator.

Check the armature and field.

LAP TM-7

Student _____

Date _____

## TESTING THE CHARGING CIRCUIT

### Instructor's Final Checklist

**Check the student's performance in the following elements of testing the charging circuit.**

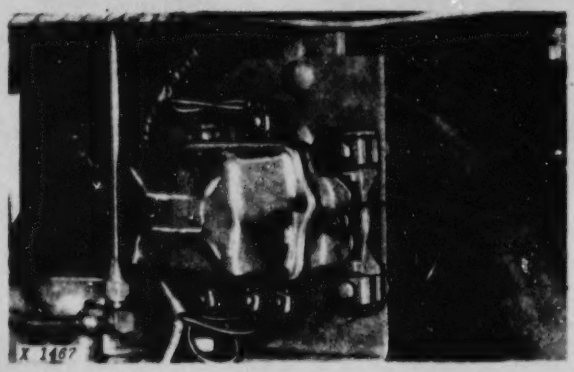
**Place an X in the appropriate box indicating not accomplished, partially accomplished, or fully accomplished. If, because of special circumstances, the item was impossible to complete, place an X in the "Not Applicable" box.**

**Performance Level: All items must receive a rating of FULLY ACCOMPLISHED (or Not Applicable). If any items are rated Not Accomplished or Partially Accomplished, the student and instructor will discuss this and decide which learning activities must be repeated.**

| | | Student Performance | | | |
|---|---|---|---|---|---|
| | | Not Applicable | Not Accomplished | Partially Accomplished | Fully Accomplished |
| 1. | In testing the charging circuit, the student: | | | | |
| | a. set up test equipment correctly | [ ] | [ ] | [ ] | [ ] |
| | b. tested the circuit at a 10 amp load | [ ] | [ ] | [ ] | [ ] |
| | c. adjusted voltmeter reading for temperature with the engine at operating temperature | [ ] | [ ] | [ ] | [ ] |
| | d. got the same readings as the instructor | [ ] | [ ] | [ ] | [ ] |
| 2. | In testing the generator, the student: | | | | |
| | a. set up test equipment correctly | [ ] | [ ] | [ ] | [ ] |
| | b. tested generator at recommended speed | [ ] | [ ] | [ ] | [ ] |
| | c. got the same reading as the instructor | [ ] | [ ] | [ ] | [ ] |
| 3. | In testing the armature and field, the student: | | | | |
| | a. checked visually for an open circuit | [ ] | [ ] | [ ] | [ ] |
| | b. checked for an open circuit using the growler and combination unit | [ ] | [ ] | [ ] | [ ] |
| | c. tested for shorted and grounded armature | [ ] | [ ] | [ ] | [ ] |
| | d. tested field circuit | [ ] | [ ] | [ ] | [ ] |
| | e. recorded readings which matched those taken by the instructor | [ ] | [ ] | [ ] | [ ] |

# Learning Activity Package Number 8

Objective 51-52




Courtesy of John Deere and Company

# Adjusting the Voltage Regulator

# Tractor Mechanics

## INTRODUCTION

The voltage regulator on a tractor prevents the generator from producing voltages high enough to burn out or damage the electrical system. It consists of a cut-out relay which disconnects the generator from the battery, a current regulator which controls the amperage in the circuit, and a voltage regulator which limits the voltage that is on the circuit. In this learning activity package you will learn how each of these works and how to service the voltage regulator.

## DIRECTIONS

Read the objectives below. If you believe you are already able to perform these tasks, read the Check-Out Activities on page 5 of this package. Then, either arrange with your instructor about doing the Check-Out Activities,

or

If you need to complete learning activities in order to be able to do the tasks, turn to p. 2 and go through the Learning Activities in the order given.

## OBJECTIVES

(1) Given necessary tools, voltage regulator, one-fourth ohm fixed resistor, voltmeter, and the manufacturer's service manual, adjust the voltage regulator using the fixed-resistance method. Adjustments should meet specifications in the service manual.

(2) Given necessary tools, voltage regulator, voltmeter, and the manufacturer's service manual, adjust the voltage regulator using the variable-resistance method. Adjustments should meet specifications in the manufacturer's service manual.

## LEARNING ACTIVITIES

1 READ *Fundamentals of Service: Electrical Systems* (John Deere Company), Chapter 4, pp. 4-19 through 4-30.

(or)_____

2 READ *The Tractor Electrical System* (AAVIM), pp. 40-43.

(or) _____

3 CHECK YOUR KNOWLEDGE of regulators by taking the STUDENT SELF CHECK, *Understanding Regulators.*

(or)_____

4 READ the section on voltage regulators in the manufacturer's service manual.

(or)_____

5 PRACTICE adjusting a voltage regulator to the specifications indicated in the manufacturer's service manual. Follow the directions on INSTRUCTIONS – (A) *The Fixed-Resistance Method of Voltage Regulator Adjustment*, and (B) *The Variable-Resistance Method of Voltage Regulator Adjustment.*

6 ARRANGE with your instructor to complete this learning activity package by going through the CHECK-OUT ACTIVITIES listed on page 5.

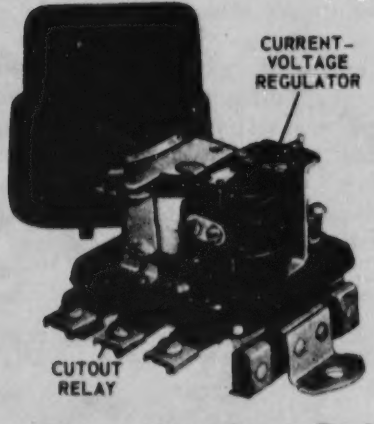



Figure 1. Cutout Relay, Current Regulator and Voltage Regulator

Courtesy of John Deere and Company

## TOOLS AND EQUIPMENT NEEDED

1. Voltage Regulator
2. Voltmeter
3. Mechanic's Tool Set

## MATERIALS AND SUPPLIES NEEDED

1. .25 OHM Fixed Resistor

## SAFETY

No special safety precautions.

## INSTRUCTIONS

### A. THE FIXED–RESISTANCE METHOD OF VOLTAGE REGULATOR ADJUSTMENT

In adjusting the voltage regulator using the fixed-resistance method, the following procedure should be used:

1. Consult the manufacturer's service manual for pertinent specifications and procedure.
2. Insert a one-fourth ohm fixed resistor into the charging circuit at the battery terminal.

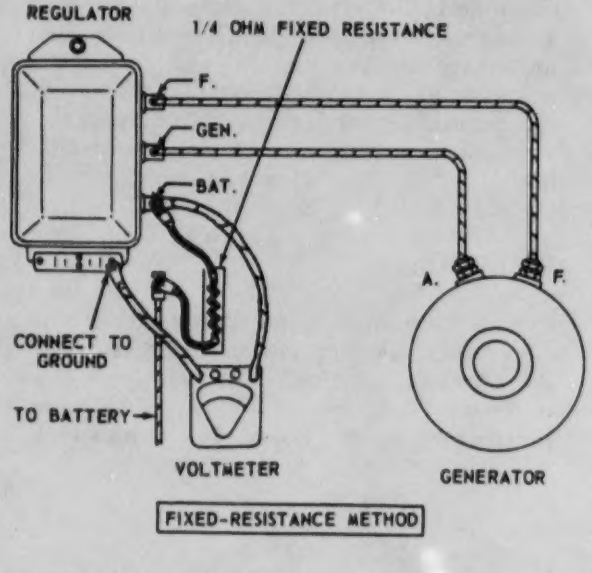



Figure 2. Checking the setting of Voltage Regulator Fixed-Resistance Method.

Courtesy of John Deere and Company

3. Connect a voltmeter from the battery terminal to ground.

4. Cycle the generator by one of two methods:

   a. Slow it down until voltage drops to about one-fourth of rated value. Then increase speed and note the reading.

   b. Cycle the generator by inserting a variable resistance into the field circuit. Slowly increase resistance until voltage drops to about one-fourth of rated value. Decrease the resistance and note the voltage reading.

Figure 3. Voltage Setting Adjustment

Courtesy of John Deere and Company

5. Adjust the voltage setting by turning the adjusting screw. If the adjusting screw is turned to its limit, it may be necessary to bend the spring support. However, do this very carefully. Final adjustment should always be made by increasing the spring tension. If the setting is too high, adjust the unit below the specified value and then bring it back to this value by increasing the spring tension. After each adjustment and before taking a reading, replace the cover and cycle the generator.

## B. THE VARIABLE–RESISTANCE METHOD OF VOLTAGE REGULATOR ADJUSTMENT

In adjusting the voltage regulator using the variable-resistance method, the following procedure should be used:

1. Connect a variable resistor and an ammeter into the charging circuit at the battery terminal.

2. Connect a voltmeter from the battery terminal to ground.

3. Start generator and adjust resistor to get a current flow of not more than 10 amperes. Operate the generator at specified speed to warm it up.

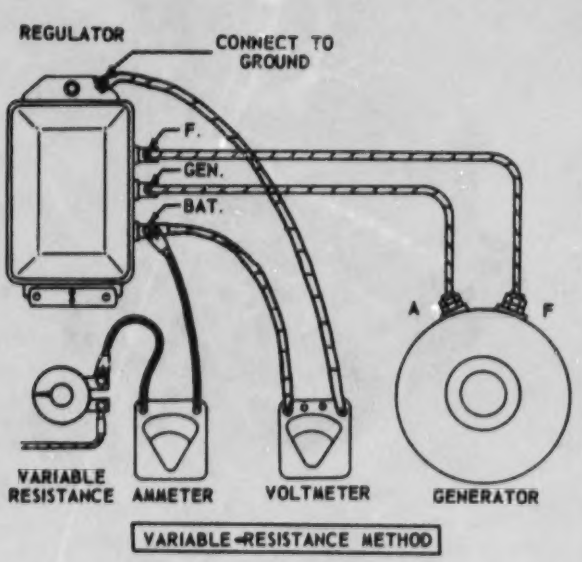



Figure 4. Checking the Voltage Setting of Voltage Regulator - Variable Resistance

Courtesy of John Deere and Company

4. Cycle the generator by one of two methods:

   a. Slow it down until voltage drops to about one-fourth of rated value. Then increase speed and note the reading.

   b. Cycle the generator by inserting a variable resistance into the field circuit. Slowly increase resistance until voltage drops to about one-fourth of rated value. Decrease the resistance and note the voltage reading.

**Figure 5. Adjusting Closing Voltage of Cutout Relay**

Courtesy of John Deere and Company

5. Adjust the voltage setting by turning the adjusting screw. If the adjusting screw is turned to its limit, it may be necessary to bend the spring support. However, do this very carefully. Final adjustment should always be made by increasing the spring tension. If the setting is too high, adjust the unit below the specified value and then bring it back to this value by increasing the spring tension. After each adjustment and before taking a reading, replace the cover and cycle the generator.

**STUDENT SELF–CHECK**
*DO NOT WRITE ON THIS PAGE!*
**UNDERSTANDING REGULATORS**

1. The voltage regulator is the control mechanism for the generator or alternator. (T or F)

2. The main purpose of the cut-out relay is to open and close the circuit between the generator and the battery. (T or F)

3. The main purpose of the voltage regulator is to control the voltage output of the generator. (T or F)

4. The main purpose of the current regulator is to control the current output or amperage of the generator. (T or F)

5. Resistors reduce a sudden surge of voltage in the field coils. (T or F)

6. How many resistors are used in the regulator circuit?

7. The cut-out relay is connected to the generator and _____.

8. The current regulator is connected to the generator and _____.

9. The voltage regulator component is connected to the regulator and _____.

10. Match the following:

| | | | |
|---|---|---|---|
| a. | The "BAT" terminal on the regulator | 1. | The generator field winding |
| b. | The "GEN" terminal on the regulator | 2. | The generator armature winding |
| c. | The "FIELD" terminal on the regulator | 3. | The battery |

Compare your answers with the correct responses on the following page. Review any incorrect answers before going on to the next Learning Activity.

## CORRECT RESPONSES

1. True
2. True
3. True
4. True
5. True
6. two
7. battery
8. cut-out relay
9. ground
10. a. 3
    b. 2
    c. 1

## CHECK–OUT ACTIVITIES

The statements below explain the activities you must be able to complete in order to finish this learning activity package. As you go through each activity, your instructor will rate your performance using the Instructor's Final Checklist, *ADJUSTING THE VOLTAGE REGULATOR.*

On the designated tractor:

Adjust the voltage regulator using the fixed-resistance method.

Adjust the voltage regulator using the variable-resistance method.

DO NOT WRITE ON THIS PAGE

LAP TM–8

Student _____

Date _____

## ADJUSTING THE VOLTAGE REGULATOR

### Instructor's Final Checklist

Check the student's performance in the following elements of adjusting the voltage regulator.

Place an X in the appropriate box indicating not accomplished, partially accomplished, or fully accomplished. If, because of special circumstances, the item was impossible to complete, place an X in the "Not Applicable" box.

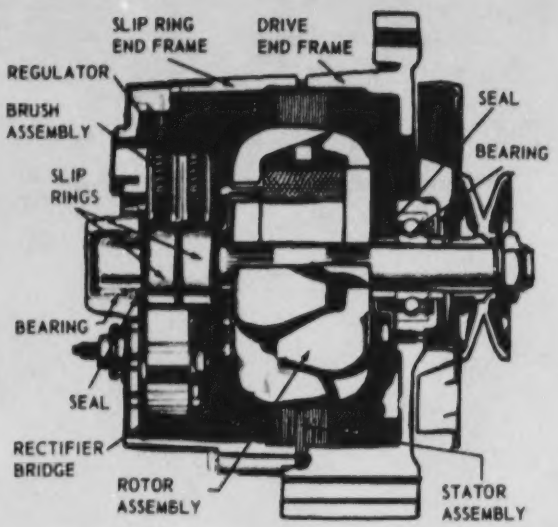
Performance Level: All items must receive a rating of FULLY ACCOMPLISHED (or Not Applicable). If any items are rated Not Accomplished or Partially Accomplished, the student and instructor will discuss this and decide which learning activities must be repeated.

In adjusting the voltage regulator, the student:

| | Student Performance | | | |
|---|---|---|---|---|
| | Not Applicable | Not Accomplished | Partially Accomplished | Fully Accomplished |
| 1. checked the manufacturer's service manual for specifications | [ ] | [ ] | [ ] | [ ] |
| 2. checked the voltage readings using a voltmeter | [ ] | [ ] | [ ] | [ ] |
| 3. adjusted the voltage to the value specified in the manufacturer's service manual | [ ] | [ ] | [ ] | [ ] |
| 4. checked the current reading using an ammeter | [ ] | [ ] | [ ] | [ ] |
| 5. adjusted the amperage to the value specified in the manufacturer's service manual | [ ] | [ ] | [ ] | [ ] |
| 6. cleaned all parts of the regulator system | [ ] | [ ] | [ ] | [ ] |

# Learning Activity Package Number 9

Objective 58-60-61-62




Courtesy of John Deere and Company

## Servicing the Alternator

## Tractor Mechanics

### INTRODUCTION

Late-model tractors use an A.C. alternator system to produce electric current instead of the older D.C. generator. The alternator is more efficient and causes fewer problems than the D.C. generator. A battery can only be charged by direct current. The alternator produces alternating current, and therefore must have a filter system to change A.C. to D.C. In this learning activity package you will learn how to service alternator systems.

### DIRECTIONS

Read the objectives below. If you believe you are already able to perform these tasks, read the Check-Out Activities on page 5 of this package. Then, either arrange with your instructor about doing the Check-Out Activities,

or

If you need to complete learning activities in order to be able to do these tasks, turn to p. 2 and go through the Learning Activities in the order given.

### OBJECTIVES

(1) Given necessary tools and equipment, and the manufacturer's service manual, test the alternator regulator. The results of service and adjustments should be 100% accurate as indicated in the service manual.

(2) Given a 1½ ohm ohmmeter and necessary tools and equipment, test the alternator diode. The reading on the ohmmeter should be 100% accurate when compared to the reading obtained by the instructor.

(3) Given an appropriate press, an alternator, soldering iron, pliers, and necessary tools, replace a diode. The replacement process should include the completion of all the steps on the instructor's final checklist.

(4) Given a charging system with a faulty heat sink, a new heat sink, the manufacturer's service manual, the needed wrenches, alternator and soldering iron, replace the heat sink. The heat sink will be in position as designated by the specific alternator. The diodes should function correctly based on an alternator diode test.

## LEARNING ACTIVITIES

1 READ *Fundamentals of Service: Electrical Systems* (John Deere Company), Chapter 1, pp. 10-11; Chapter 4, pp. 4-37 through 4-40.

(or)_____

2 READ INSTRUCTIONS – *Servicing the Alternator.*

(or)_____

3 READ the section on alternators in the manufacturer's service manual.

(or)_____

4 CHECK YOUR KNOWLEDGE by taking STUDENT SELF–CHECK, *Servicing the Alternator.*

5 PRACTICE testing the alternator regulator and the diode, and replacing the diode and the heat sink. Follow the directions given in the manufacturer's service manual and in INSTRUCTIONS – *Servicing the Alternator.*

6 ARRANGE with your instructor to complete this learning activity package by going through the CHECK-OUT ACTIVITIES listed on page 5.

## TOOLS AND EQUIPMENT NEEDED

1. Mechanic's Tool Set
2. 1.5 Ohm Ohmmeter
3. Press
4. Soldering Iron

## MATERIALS AND SUPPLIES NEEDED

1. Alternator
2. New Heat Sink

## SAFETY

No special safety precautions necessary

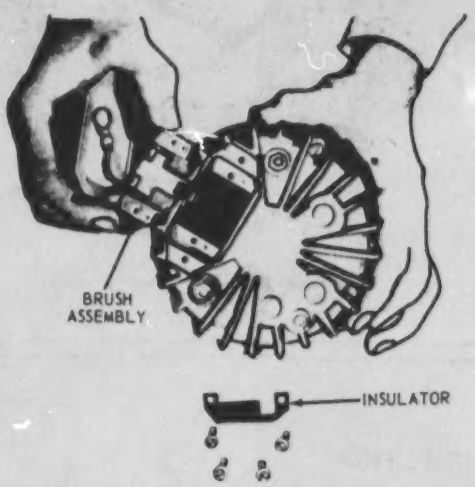



Figure 1. Removing the Brush Assembly

Courtesy of John Deere and Company

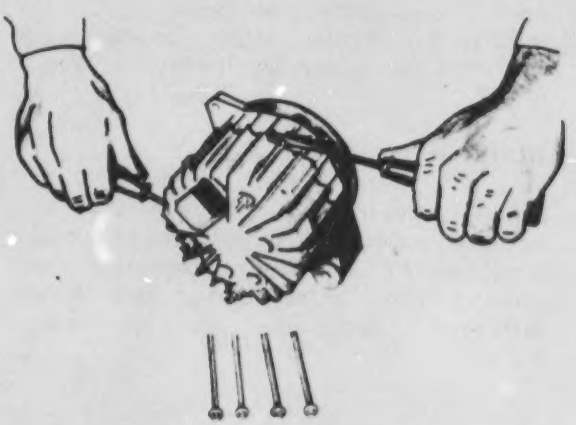


Figure 2. Removing the Slip Ring End Frame

Courtesy of John Deere and Company

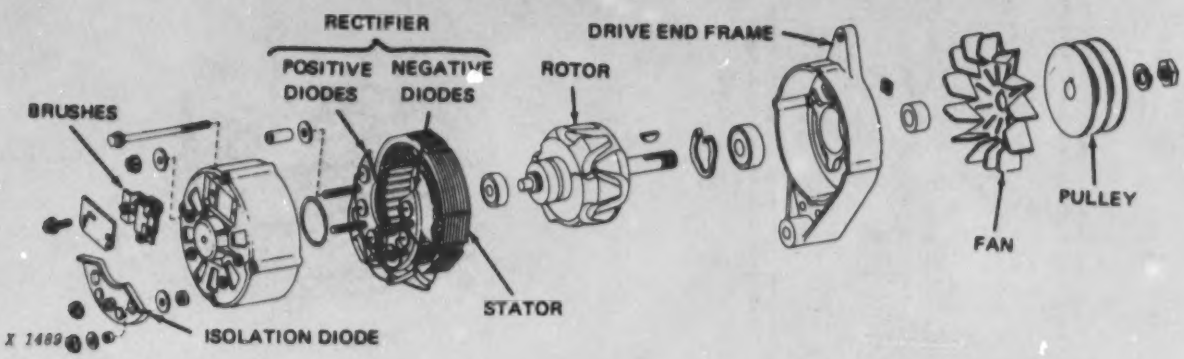



Figure 3. Exploded View of a Typical Alternator

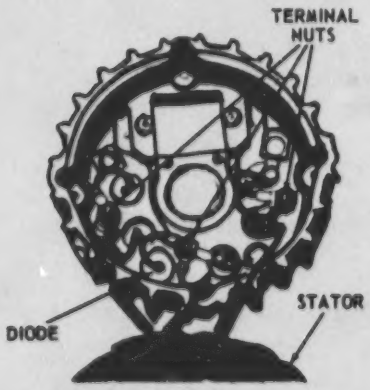
Courtesy of John Deere and Company

## INSTRUCTIONS

## SERVICING THE ALTERNATOR

In servicing the alternator regulator, the following procedure should be used:

1. Refer to the manufacturer's service manual for specific instructions for operation of test equipment and alternator regulator.
2. Turn the adjusting screw to the desired output.
3. Test charging circuit using voltmeter, ammeter, and low-carbon pile.
4. Most transistorized regulators cannot be repaired; faulty transistorized regulators should be replaced.




Closed Type - Remove Terminal Leads

Figure 4. Removing Diode Assemblies

Courtesy of John Deere and Company

In testing diodes, the following procedure should be used:

1. Connect one ohmmeter lead to the diode case and the other ohmmeter lead to the diode lead.
2. Note the ohmmeter reading.
3. Reverse the ohmmeter leads and note the reading. A good diode will give a high and low reading. If only a slight difference in reading is noted from one diode lead to the other diode lead, the diode is probably defective.

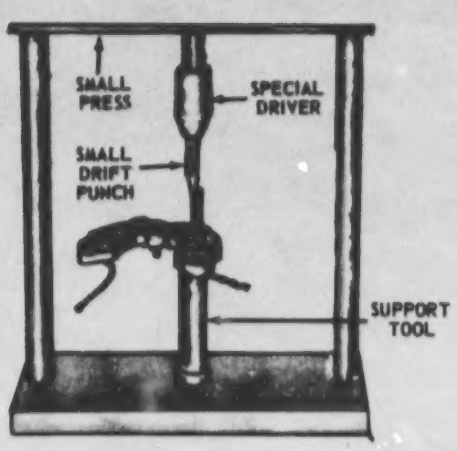



Figure 5. Removing Old Diode

Courtesy of John Deere and Company

In replacing a diode, the following procedure should be used:

1. Locate defective diode.
2. Unsolder diode leads, using low heat and protecting diode from heat.
3. Press old diode out of the plate.
4. Press new diode into position.
5. Solder leads.
6. Check diode for proper function.

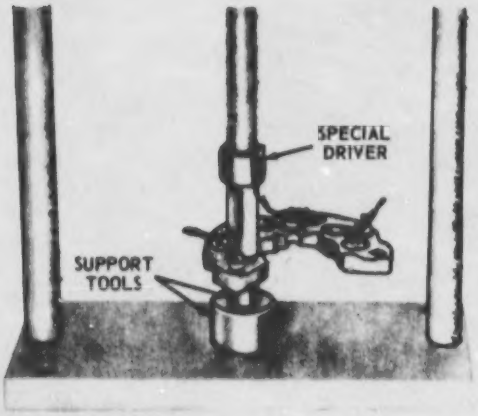



Figure 6. Replacing Individual Diodes (Closed-Type Alternators Only)

Courtesy of John Deere and Company

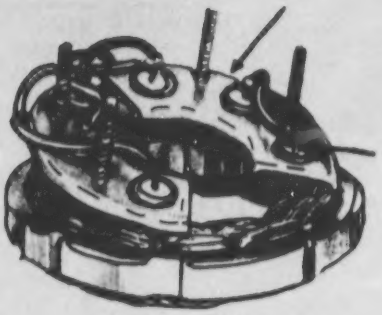


Figure 7. Heat Sink

Courtesy of John Deere and Company

In replacing a heat sink, the following procedure should be used:

1. Remove all parts necessary to reach heat sink by following instructions in the manufacturer's service manual.
2. Unsolder the leads from the diodes to the stator winding.
3. Unbolt the heat sink assembly.
4. Bolt new assembly in place.
5. Solder leads from the diode to the stator winding.
6. Reassemble all parts that were removed.

## STUDENT SELF–CHECK

*DO NOT WRITE ON THIS PAGE!*

## SERVICING THE ALTERNATOR

1. Never operate the alternator on an open circuit. All three circuit components must be connected. (T or F)
2. Never attempt to polarize an alternator. (T or F)
3. The two main alternator types are the _____ alternator and the _____ alternator.

4. An alternator is a D.C. generator. (T or F)

5. Alternator = moving rotor + fixed stator + diode rectifier. (T or F)

6. An alternator works on the same principle as a generator. (T or F)

Compare your answers with the correct responses at the bottom of this page. Review any incorrect answers before you go on to the next learning activity.

## CHECK–OUT ACTIVITIES

The statements below explain the activities you must be able to complete in order to finish this learning activity package. As you go through each activity, your instructor will rate your performance using the Instructor's Final Checklist, SERVICING THE ALTERNATOR.

In the alternator on the designated tractor:

Service the alternator regulator.

Test the diode.

Replace a diode.

Replace the heat sink.

## CORRECT RESPONSES

1. True
2. True
3. Closed-type, Open-type
4. False
5. True
6. False

DO NOT WRITE ON THIS PAGE

LAP TM–9

Student _____

Date _____

## SERVICING THE ALTERNATOR

### Instructor's Final Checklist

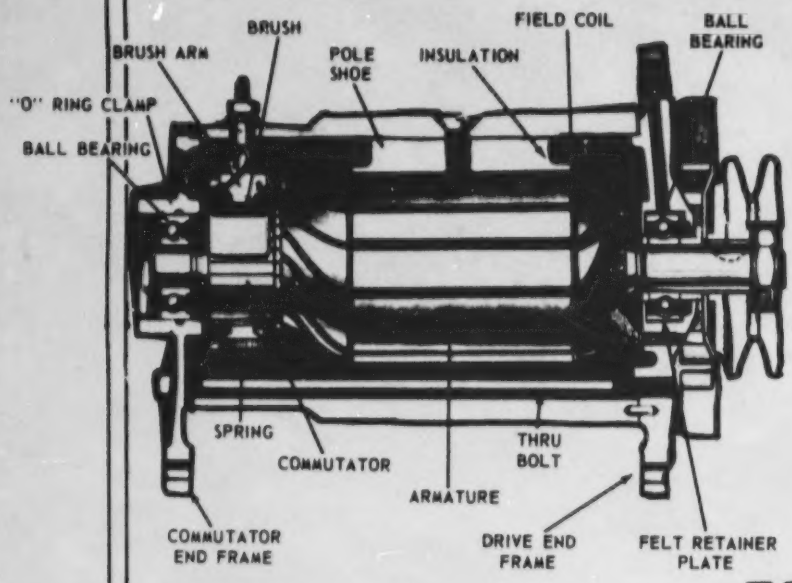
Check the student's performance in the following elements of servicing the alternator.

Place an X in the appropriate box indicating not accomplished, partially accomplished, or fully accomplished. If, because of special circumstances, the item was impossible to complete, place an X in the "Not Applicable" box.

Performance Level: All items must receive a rating of FULLY ACCOMPLISHED (or Not Applicable). If any items are rated Not Accomplished or Partially Accomplished, the student and instructor will discuss this and decide which learning activities must be repeated.

| | Student Performance | | | |
|---|---|---|---|---|
| | Not Applicable | Not Accomplished | Partially Accomplished | Fully Accomplished |
| In servicing the alternator, the student: | | | | |
| 1. checked the manufacturer's service manual for instructions on testing the alternator regulator | [ ] | [ ] | [ ] | [ ] |
| 2. made adjustments as recommended in the manufacturer's service manual | [ ] | [ ] | [ ] | [ ] |
| 3. checked both high and low sides of the diode | [ ] | [ ] | [ ] | [ ] |
| 4. replaced the defective diode | [ ] | [ ] | [ ] | [ ] |
| 5. located, removed and replaced the heat sink | [ ] | [ ] | [ ] | [ ] |
| 6. checked each unit for proper operation and made any needed adjustments | [ ] | [ ] | [ ] | [ ] |

# Learning Activity Package Number 10




Courtesy of John Deere and Company

Objectives 54–57–59–64

## Servicing the Generator

## Tractor Mechanics

### INTRODUCTION

The generator on a tractor serves a double purpose: (1) it charges the battery, and (2) it provides most of the electrical current that is needed to operate the tractor. If the generator doesn't function properly, it will be necessary to repair or replace it in order to operate the tractor very long. In this learning activity package you will learn how to maintain and repair the generator.

### DIRECTIONS

Read the objectives below. If you believe you are already able to perform these tasks, read the Check-Out Activities on page 6 of this package. Then, either arrange with your instructor about doing the Check-Out Activities,

or

If you need to complete learning activities in order to be able to do the tasks, turn to p. 2 and go through the Learning Activities in the order given.

### OBJECTIVES

(1) Using ignition tools, polarize the tractor generator on the designated tractor.

(2) Using new brushes, necessary tools and equipment, replace the brushes on the designated generator. The replacement process should include the successful completion of all the steps on an instructor checklist.

(3) Given a new set of bearings, the manufacturer's service manual, a mechanic's tool set, and an arbor press, replace the bearings in a generator. When service is complete, the armature will run free with no side play.

(4) Given an armature-turning tool, micrometer, and other necessary tools, turn an armature. The micrometer reading should be equal to the reading obtained by the instructor.

## LEARNING ACTIVITIES

1 READ *Tractor Maintenance: Principles and Procedures* (AAVIM) pp. 102-108.

(or) _____

2 READ INSTRUCTIONS, SERVICING THE GENERATOR.

(or) _____

3 READ the section on generators in the manufacturer's service manual.

(or) _____

4 READ *Fundamentals of Service: Shop Tools* (John Deere Co.), the section on micrometers, pp. 24-26.

(or) _____

5 CHECK YOUR KNOWLEDGE servicing the generator by taking the Student Self-Check, SERVICING THE GENERATOR.

6 PRACTICE removing a generator, replacing the brushes, checking the armature and polarizing the generator, Follow the directions given in the manufacturer's service manual or follow the instructions given on p. 4.

7 ARRANGE with your instructor to complete this learning activity package by going through the CHECK-OUT ACTIVITIES listed on page 6.

Figure 1. Brushes worn to less than half their original length should be replaced.

Courtesy of the American Association for Vocational Instructional Materials

## TOOLS AND EQUIPMENT NEEDED

1. Mechanic's Tool Set
2. Ignition Tools
3. Arbor Press
4. Armature-Turning Tool
5. Micrometer

## MATERIALS AND SUPPLIES NEEDED

1. New Brushes
2. New Bearings

## SAFETY

No Special Safety Precautions

## INSTRUCTIONS

### SERVICING THE GENERATOR

In replacing the generator brushes, the following procedure should be used:

1. Check the manufacturer's service manual for specifications.
2. Wipe dirt from generator housing.
3. Remove cover band.
4. Disconnect the brush wire lead where it connects to the brush holder.
5. Lift brush tension clip.

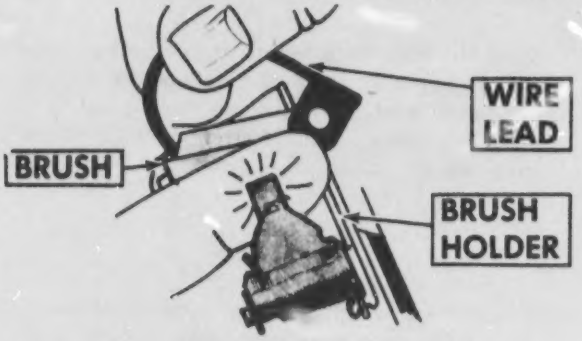



Figure 2. Removing a brush.

Courtesy of the American Association for Vocational Instructional Materials

6. Remove old brushes.

7. Clean commutator with sandpaper; thoroughly wipe clean.

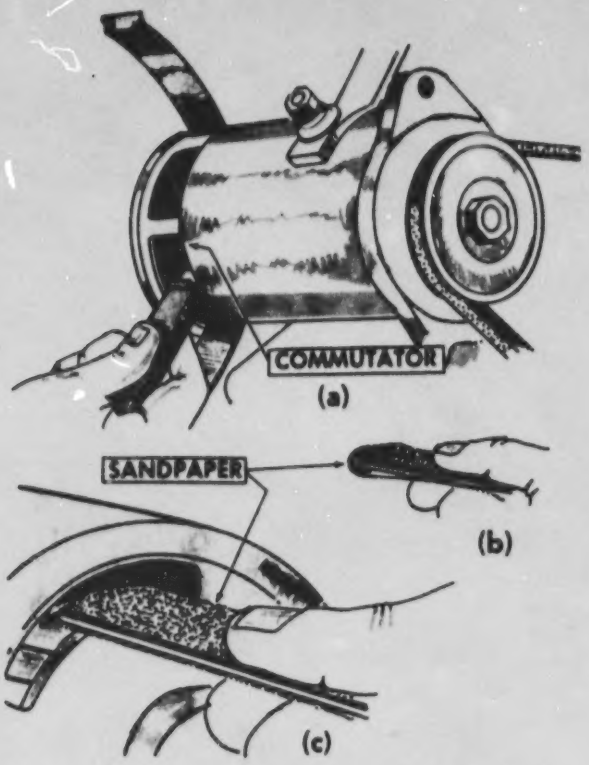



Figure 3. (a) Brush-seating stone used for cleaning commutators and seating new brushes. (b) No. 00 sandpaper used for cleaning a commutator. (c) Commutator cleaned through opening in end plate if generator has no cover band.

Courtesy of the American Association for Vocational Instructional Materials

8. Slip new brushes into place.

9. Reconnect brush wire lead.

10. Replace cover band.

11. Polarize the generator.

In replacing the bearings on the generator, the following procedure should be used:

1. Identify defective bearing based on the side play in the armature.

2. Disassemble alternator or generator following instructions in the manufacturer's service manual.

3. Press defective bearing from housing and press new bearing into housing.

4. Reassemble alternator or generator.

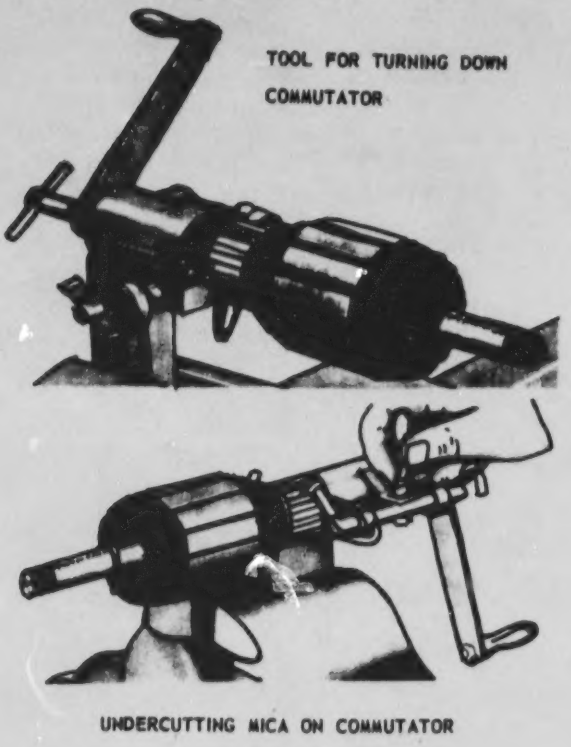



Figure 4. Reconditioning the Commutator

Courtesy of John Deere and Company

In turning an armature, the following procedure should be used:

1. Fasten the armature in the tool for turning down an armature (Fig. 4).

2. Turn the armature until smooth and round.

3. Test the armature for grounds, shorts, and balance.

In polarizing the generator (giving correct direction to the flow of current), the following procedure should be used:

1. Polarize the generator on *externally* grounded generators by touching a short, insulated jumper wire momentarily between the two posts on the regulator marked "Bat" and "Gen" (sometimes marked "Arm").

2. Polarize the generator on *internally* grounded generator by momentarily touching the ends of the "Bat" wire and the "FLD" wire together.

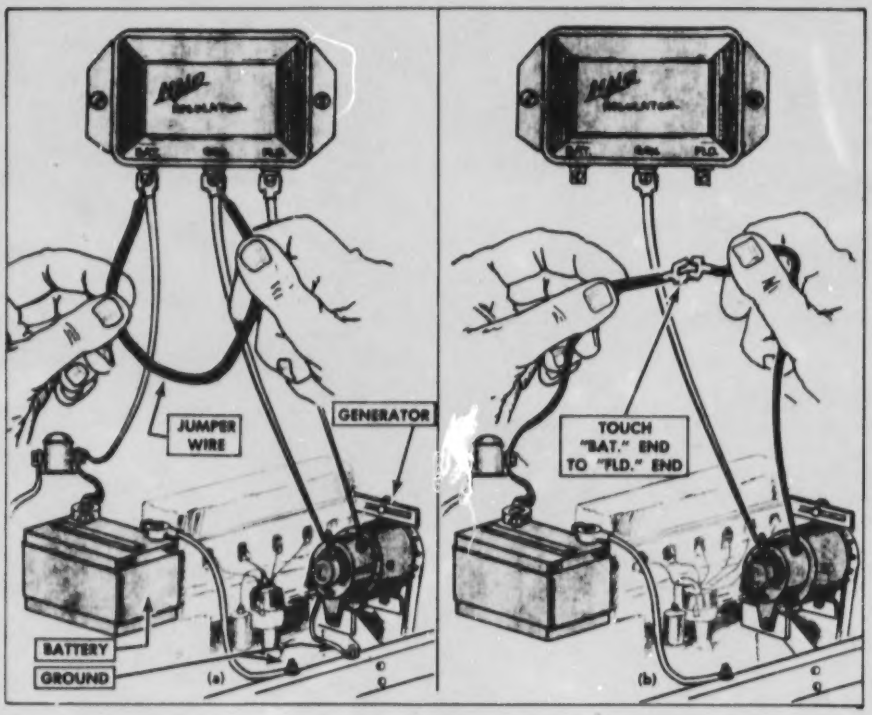



**Figure 5. To polarize an externally grounded generator (a) touch a short jumper wire to the "BAT" and "GEN" (or "ARM") posts of the regulator momentarily. On an internally grounded generator (b) touch the ends of the "BAT" and "FLD" wires together momentarily.**

Courtesy of the American Association for Vocational Instructional Materials

**STUDENT SELF-CHECK**
*DO NOT WRITE ON THIS PAGE!*
**SERVICING THE GENERATOR**

1. Generator brushes should be replaced when:

   a. they show any signs of wear
   b. if worn to less than half their original length
   c. anytime the tractor battery does not have sufficient charge to start the tractor
   d. anytime the generator does not produce current

2. Polorizing the generator is necessary in order that:

   a. the generator will operate
   b. the current flows in the desired direction

3. An externally grounded generator is polorized by:

   a. touching a short jumper wire to the "BAT" and "GEN" (or "ARM") posts of the regulator momentarily
   b. touching the ends of "BAT" and "FLO" wires together momentarily

CORRECT RESPONSES

1.b, 2.b, 3.a

## CHECK-OUT ACTIVITIES

The statements below explain the activities you must be able to complete in order to finish this learning activity package. As you go through each activity, your instructor will rate your performance using the Instructor's Final Checklist, SERVICING THE GENERATOR.

On the designated tractor:

Polarize the generator.

Change the generator brushes.

Replace the bearings in the generator.

Turn the armature.

DO NOT WRITE ON THIS PAGE

LAP TM–10

Student _____

Date _____

## SERVICING THE GENERATOR

### Instructor's Final Checklist

Check the student's performance in the following elements of servicing the generator.

Place an X in the appropriate box indicating not accomplished, partially accomplished, or fully accomplished. If, because of special circumstances, the item was impossible to complete, place an X in the "Not Applicable" box.

Performance Level: All items must receive a rating of FULLY ACCOMPLISHED (or Not Applicable). If any items are rated Not Accomplished or Partially Accomplished, the student and instructor will discuss this and decide which learning activities must be repeated.

In servicing the generator, the student:

| | Student Performance | | | |
|---|---|---|---|---|
| | Not Applicable | Not Accomplished | Partially Accomplished | Fully Accomplished |
| 1. checked the manufacturer's service manual for specifications | [ ] | [ ] | [ ] | [ ] |
| 2. removed the generator from the engine | [ ] | [ ] | [ ] | [ ] |
| 3. cleaned the generator housing | [ ] | [ ] | [ ] | [ ] |
| 4. removed and properly replaced the generator brushes | [ ] | [ ] | [ ] | [ ] |
| 5. inspected the bearings and replaced if defective | [ ] | [ ] | [ ] | [ ] |
| 6. turned the armature until it was smooth and round | [ ] | [ ] | [ ] | [ ] |
| 7. checked the armature with a micrometer | [ ] | [ ] | [ ] | [ ] |
| 8. reassembled the generator and checked for smoothness of operation | [ ] | [ ] | [ ] | [ ] |
| 9. replaced the generator on the tractor engine | [ ] | [ ] | [ ] | [ ] |
| 10. polarized the system | [ ] | [ ] | [ ] | [ ] |
| 11. tested the charging circuit | [ ] | [ ] | [ ] | [ ] |

# Learning Activity Package Number 11

Objective 56

Courtesy of the American Association for Vocational Instructional Materials

## Replacing an Amperage Gauge

## Tractor Mechanics

### INTRODUCTION

The amperage gauge on a tractor provides a means for knowing when the charging system is operating correctly. The gauge is connected in series with the electrical system so that the current used must pass through the gauge. When the charging system is functioning (working) properly, the gauge indicator (usually a needle) will move to the right of the center. When the system begins to discharge, the indicator moves to the left, thus warning the operator that something needs repair. In this learning activity package you will learn how to replace a defective gauge.

### DIRECTIONS

Read the objective below. If you believe you are already able to perform this task, read the Check-Out Activity on page 3 of this package. Then, either arrange with your instructor about doing the Check-Out Activity,

or

If you need to complete learning activities in order to be able to do the task, turn to p. 2 and go through the Learning Activities in the order given.

### OBJECTIVE

Given a replacement amperage gauge, and necessary tools and equipment, replace an amperage gauge on the designated tractor. The replaced gauge should function properly, and all the steps on the instructor's checklist should be completed during the replacement process.

### LEARNING ACTIVITIES

1 READ *Tractor Electrical Systems* (AAVIM), pp. 6-17.

(or) _____

2 READ Instructions, REPLACING AN AMPERAGE GAUGE

3 READ the section on gauges in the manufacturer's service manual.

(or) _____

4 Check your knowledge by taking student self-check, Replacing an Amperage Gauge.

5 PRACTICE removing and replacing the ammeter on a designated tractor. Follow the directions in the manufacturer's service manual and on INSTRUCTIONS – REPLACING AN AMPERAGE GAUGE.

6 ARRANGE with your instructor to complete this learning activity package by going through the CHECK-OUT ACTIVITIES listed on page 3.

## TOOLS AND EQUIPMENT NEEDED

1. Mechanic's Tool Set

## MATERIALS AND SUPPLIES NEEDED

1. Replacement Amperage Gauge

## SAFETY

Remove battery cable. "Hot" wires can accidentally rub against metal resulting in severe burns.

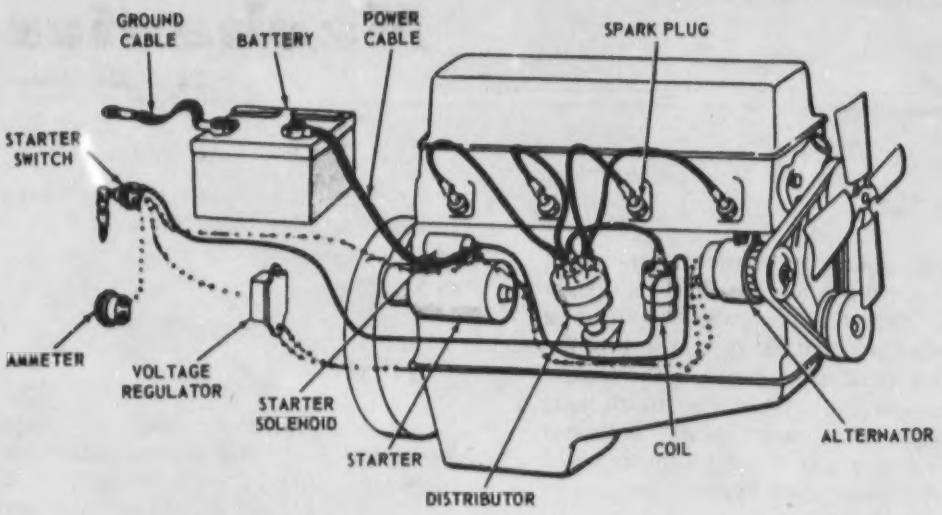



**Figure 1. Typical Electrical System For Spark-Ignition Engine**

Courtesy of John Deere and Company

## INSTRUCTIONS

### REPLACING AN AMPERAGE GAUGE

In replacing an amperage gauge, the following procedure should be used:

1. Check the manufacturer's service manual for directions.
2. Secure replacement amperage gauge.
3. Remove amperage gauge from mounting.
4. Identify source of wires connecting to amperage gauge.
5. Remove wires from old gauge and attach to new amperage gauge.
6. Install replacement amperage gauge in its mount.

### STUDENT SELF-CHECK

*DO NOT WRITE ON THIS PAGE!*

### REPLACING AN AMPERAGE GAUGE

1. An amperage reading to the left of zero, or in the negative amps region on the meter indicates the battery is charging. (True or False)
2. An amperage meter should be repaired instead of replaced. (True or False)

Compare your answers with the correct responses on this page. Review any incorrect answers before going on to the next Learning Activity.

### CHECK-OUT ACTIVITIES

The statement below explains the activity you must be able to complete in order to finish this learning activity package. As you go through the activity, your instructor will rate your performance using the Instructor's Final Checklist, REPLACING AN AMPERAGE GAUGE.

Replace the amperage gauge on the designated tractor.

## CORRECT RESPONSES

1. False
2. False

DO NOT WRITE ON THIS PAGE

LAP TM–11

Student _____

Date _____

## REPLACING AN AMPERAGE GAUGE

### Instructor's Final Checklist

Check the student's performance in the following elements of replacing an amperage gauge.

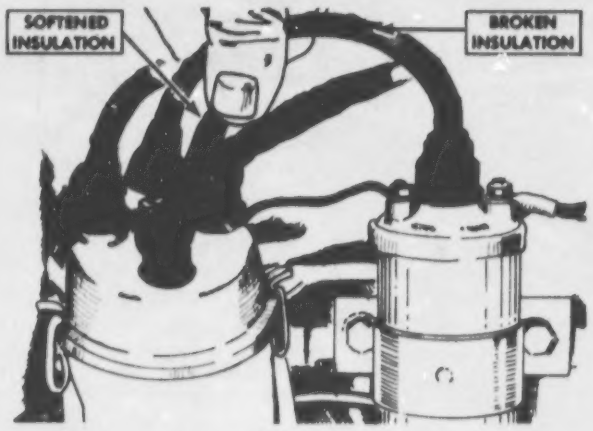
Place an X in the appropriate box indicating not accomplished, partially accomplished, or fully accomplished. If, because of special circumstances, the item was impossible to complete, place an X in the "Not Applicable" box.

Performance Level: All items must receive a rating of FULLY ACCOMPLISHED (or Not Applicable). If any items are rated Not Accomplished or Partially Accomplished, the student and instructor will discuss this and decide which learning activities must be repeated.

| | | Student Performance | | | |
|---|---|---|---|---|---|
| | | Not Applicable | Not Accomplished | Partially Accomplished | Fully Accomplished |
| In replacing an amperage gauge, the student: | | | | | |
| 1. | secured replacement gauge | [ ] | [ ] | [ ] | [ ] |
| 2. | checked the manufacturer's service manual for instructions on how to remove and replace the gauge | [ ] | [ ] | [ ] | [ ] |
| 3. | identified wires connected to the old gauge | [ ] | [ ] | [ ] | [ ] |
| 4. | removed the old gauge and installed a new one | [ ] | [ ] | [ ] | [ ] |
| 5. | checked the gauge, with all systems working, for proper operation | [ ] | [ ] | [ ] | [ ] |

# Learning Activity Package Number 12

Objectives 30-34-35




Courtesy of the American Association for Vocational Instructional Materials

## Servicing the Ignition Wires

# Tractor Mechanics

### INTRODUCTION

The spark, formed by the ignition system of an engine, ignites the fuel. As the fuel burns, it produces the power to operate the tractor. If the engine is to work efficiently, the wire that carries the sparks (or electrical impulses) must be of a specified type, length, and resistance. In this learning activity package you will learn how to remove old wiring, how to check for proper resistance, and how to install new wire to meet the manufacturer's specifications.

### DIRECTIONS

Read the objectives below. If you believe you are already able to perform these tasks, read the Check-Out Activities on page 5 of this package. Then, either arrange with your instructor about doing the Check-Out Activities,

or

If you need to complete learning activities in order to be able to do the tasks, turn to p. 2 and go through the Learning Activities in the order given.

### OBJECTIVES

(1) Given an ignition wire, service manual, ohmmeter, and necessary tools and equipment, measure the resistance of the wire within 5% of the specifications in the service manual.

(2) Given necessary tools, equipment, wire material, and the manufacturer's service manual, replace the primary ignition wire on the designated tractor. Wire size and resistance reading should be 100% accurate as indicated by the manufacturer's specifications. The replaced wire should be properly connected to the distributor and coil.

(3) Given necessary tools, equipment, material, and the manufacturer's service manual, replace the secondary ignition wires. Wire size and resistance reading should be 100% accurate as indicated by the manufacturer's specifications. The replaced wire should be properly connected to the distributor and spark plug.

## LEARNING ACTIVITIES

1. READ the sections "Resistance" and "Measuring Voltage, Current and Resistance" in *The Tractor Electrical System* (AAVIM), pp.5-6 and 6-18.

   (or) _____

2. READ Chapter 2, "Testing Tools and Equipment," in *Fundamentals of Service: Electrical Systems* (John Deere Co.), pp. 2-1 through 2-9.

   (or) _____

3. CHECK YOUR KNOWLEDGE of the test equipment by taking Student Self-Check, USING ELECTRICAL TEST EQUIPMENT.

4. READ the section on ignition wires in the manufacturer's service manual.

   (or) _____

5. READ INSTRUCTIONS, SERVICING THE IGNITION WIRES.

   (or) _____

6. ASK YOUR INSTRUCTOR to show you the proper way to set up and use the test equipment.

   (or) _____

7. PRACTICE removing ignition wiring, checking resistance, and preparing and replacing new wiring. Follow the procedure outlined in Learning Activity 5.

8. ARRANGE with your instructor to complete this learning activity package by going through the CHECK-OUT ACTIVITIES listed on page 5.

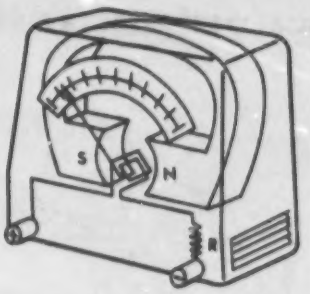



Figure 1. Voltmeter

Courtesy of John Deere and Company

## TOOLS AND EQUIPMENT NEEDED

1. Ohmmeter
2. Mechanics Tool Set

## MATERIALS AND SUPPLIES NEEDED

1. Ignition Wire
2. Wire Material

## SAFETY

No Special Safety Precautions

## INSTRUCTIONS

### SERVICING THE IGNITION WIRES

In measuring the resistance in a piece of wire, the following procedure should be used:

1. Calibrate the ohmmeter.
2. Check wire specifications in service manual.
3. Attach ohmmeter leads to ignition wire.
4. Read ohmmeter scale to determine the resistance.

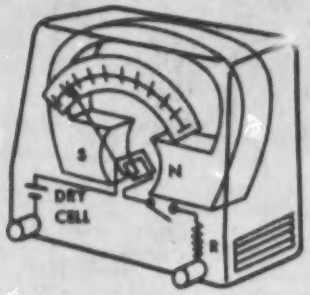



Figure 2. Ohmmeter

Courtesy of John Deere and Company

In replacing the primary ignition wire on the designated tractor, the following procedure should be used:

1. Get information on wire size from service manual.
2. Identify end of primary wire.
3. Remove wire.
4. Check wire for resistance using an ohmmeter.
5. Check wire size.
6. Prepare replacement: cut new wire to proper length and replace terminals using crimpers.
7. Check new wire with ohmmeter for manufacturer's specifications.
8. Replace wire and connect to system.

In replacing the secondary ignition wire on the designated tractor, the following procedure should be used:

1. Get information on wire size from service manual.
2. Determine rotation and firing order.
3. Remove and number spark plug wires.
4. Cut new wires to specified length or resistance as required by the manufacturer (carbon or resistance).
5. Install dust covers and terminals; crimp in place.
6. Reinstall wires on engine, beginning with no. 1 wire to no. 1 plug. Continue replacing the rest of the wires following the engine firing order. (Note: Check manufacturer's specifications to find out which wires must not be close together.)
7. Check for proper operation.

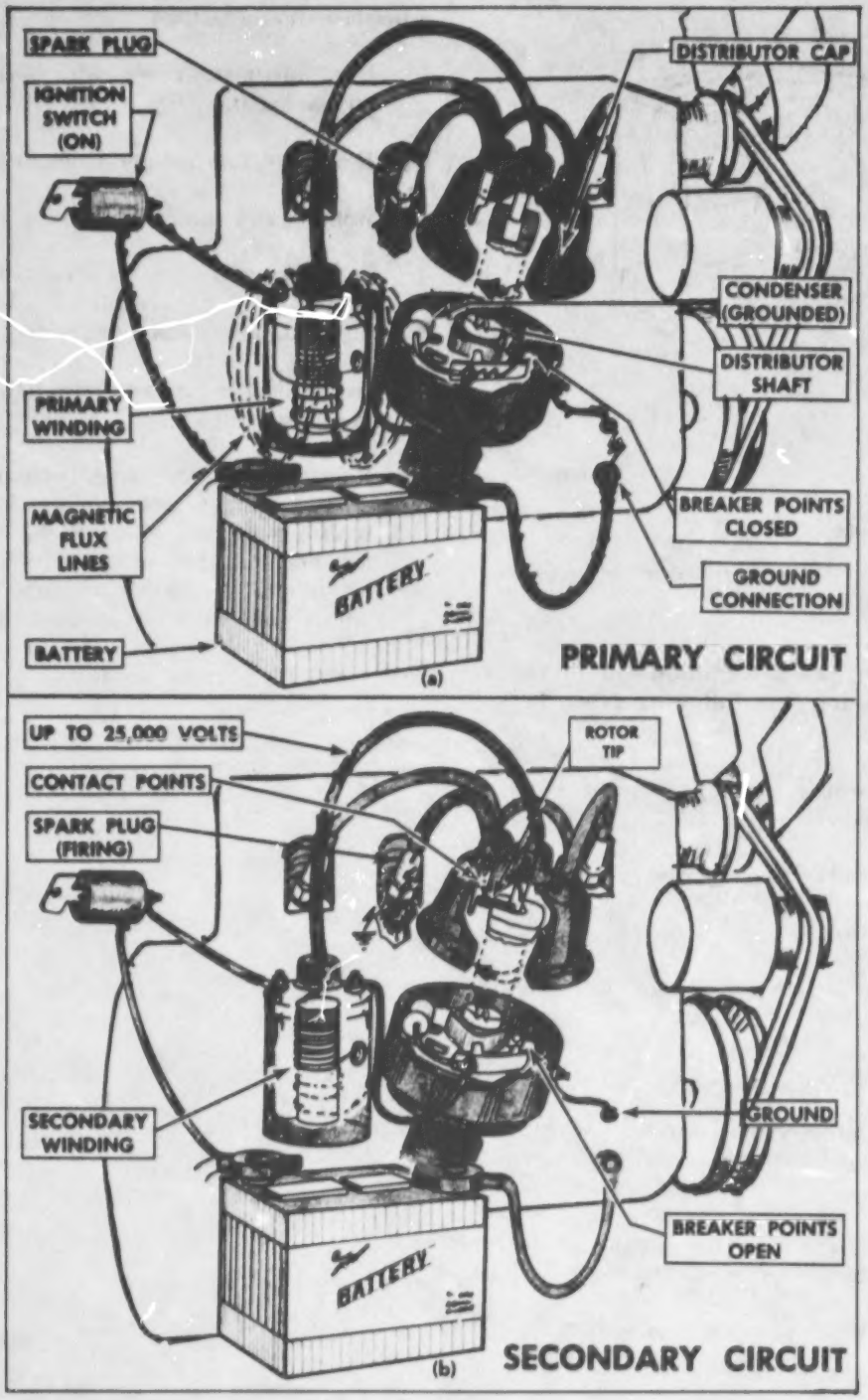



**Figure 3. Primary and secondary ignition circuits on a gasoline-powered engine.**

Courtesy of the American Association for Vocational Instructional Materials

**STUDENT SELF-CHECK**
*DO NOT WRITE ON THIS PAGE!*
**USING ELECTRICAL TEST EQUIPMENT**

1. The three basic electrical test instruments are:
   a.
   b.
   c.

2. _____are connected into the electrical circuit.

3. _____are connected in parallel with the circuit.

4. _____are used to check wiring for resistance, and to check for open or broken wire.

5. When two electrical wires are touching they are said to be _____.

6. An electrical wire touching bare metal would be _____.

Compare your answers with the correct responses at the bottom of this page. Review any incorrect answers before you go on to the next learning activity.

**CORRECT RESPONSES**

1. a. voltmeter
   b. ohmmeter
   c. ammeter
2. ammeters
3. voltmeters
4. ohmmeters
5. shorted
6. grounded

**CHECK-OUT ACTIVITIES**

The statements below explain the activities you must be able to complete in order to finish this learning activity package. As you go through each activity, your instructor will rate your performance using the Instructor's Final Checklist, SERVICING THE IGNITION WIRES.

Measure the resistance in a piece of ignition wire.

Replace the primary ignition wire on the designated tractor.

Replace the secondary ignition wires on the designated tractor.

DO NOT WRITE ON THIS PAGE

LAP TM–12

Student _____

Date _____

## SERVICING THE IGNITION WIRES

### Instructor's Final Checklist

Check the student's performance in the following elements of servicing the ignition wires.

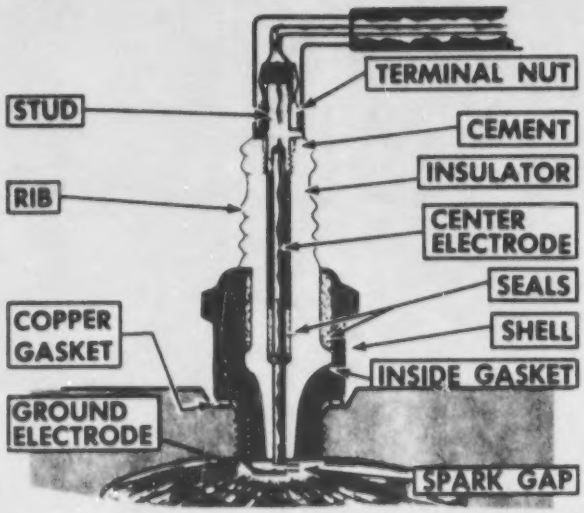
Place an X in the appropriate box indicating not accomplished, partially accomplished, or fully accomplished. If, because of special circumstances, the item was impossible to complete, place an X in the "Not Applicable" box.

Performance Level: All items must receive a rating of FULLY ACCOMPLISHED (or Not Applicable). If any items are rated Not Accomplished or Partially Accomplished, the student and instructor will discuss this and decide which learning activities must be repeated.

| | | Student Performance | | | |
|---|---|---|---|---|---|
| | | Not Applicable | Not Accomplished | Partially Accomplished | Fully Accomplished |
| In servicing the ignition wires the student: | | | | | |
| 1. | checked manufacturer's service manual for wire specifications | [ ] | [ ] | [ ] | [ ] |
| 2. | used ohmmeter to check wire for resistance | [ ] | [ ] | [ ] | [ ] |
| 3. | cut new wire to proper length | [ ] | [ ] | [ ] | [ ] |
| 4. | used crimpers when replacing terminals | [ ] | [ ] | [ ] | [ ] |
| 5. | determined rotation and firing order | [ ] | [ ] | [ ] | [ ] |
| 6. | removed and numbered spark plug wires | [ ] | [ ] | [ ] | [ ] |
| 7. | reinstalled all wiring, using proper sequence | [ ] | [ ] | [ ] | [ ] |
| 8. | checked for proper operation | [ ] | [ ] | [ ] | [ ] |
| 9. | drew from memory a rough sketch of the ignition system used on most farm tractors | [ ] | [ ] | [ ] | [ ] |

# Learning Activity Package Number 13

Objective 36




Courtesy of the American Association for Vocational Instructional Materials

## Servicing Spark Plugs

## Tractor Mechanics

### INTRODUCTION

Tractor operators seldom think of servicing spark plugs, yet good plugs, properly gapped, are vital to the operation of a gasoline engine. Good plugs can increase horsepower by 20% or more and can decrease fuel use as much as 14%. In this learning activity package you will learn how to correctly service and install spark plugs.

### DIRECTIONS

Read the objective below. If you believe you are already able to perform this task, read the Check-Out Activity on page 4 of this package. Then, either arrange with your instructor about doing the Check-Out Activity,

or

If you need to complete learning activities in order to be able to perform the task, turn to p. 2 and go through the Learning Activities in the order given.

### OBJECTIVE

Given a spark plug, a manufacturer's service manual, and the necessary tools and equipment, service the plug and set the gap to 100% accuracy as specified by the manufacturer's service manual.

### LEARNING ACTIVITIES

1 READ Chapter 2, "Maintaining Spark Plugs," in *Tractor Maintenance: Principles and Procedures* (AAVIM), pp. 54-63.

(or) _____

2 READ the section on spark plugs in the manufacturer's service manual. Note the type of plug, recommended gap setting, and any precautions.

(or) _____

3 READ INSTRUCTIONS, SERVICING SPARK PLUGS.

(or)_____

4 CHECK your knowledge by taking Student Self-Check, Servicing Spark Plugs.

(or)_____

5 PRACTICE removing plugs, cleaning, setting gap, and reinstalling. Follow the procedure outlined in Learning Activity 3.

6 ARRANGE with your instructor to complete this learning activity package by going through the CHECK-OUT ACTIVITIES listed on page 4.

## TOOLS AND EQUIPMENT NEEDED

1. Spark Plug Wrench
2. Wire Feeler Gauge
3. Ignition File
4. Pen Knife
5. Wire Brush
6. Small Paint Brush
7. Torque Wrench
8. Sand Blast Machine

## MATERIALS AND SUPPLIES NEEDED

1. Spark Plug
2. Cleaning Solvent

## SAFETY

No Special Precautions

## INSTRUCTIONS

## SERVICING SPARK PLUGS

In servicing spark plugs, the following procedure should be used:

1. Check manufacturer's service manual for proper gap setting.
2. Remove spark plug wire.

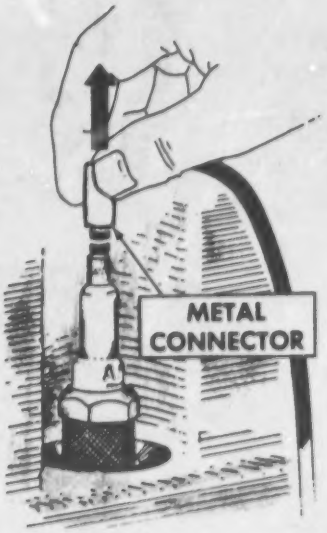
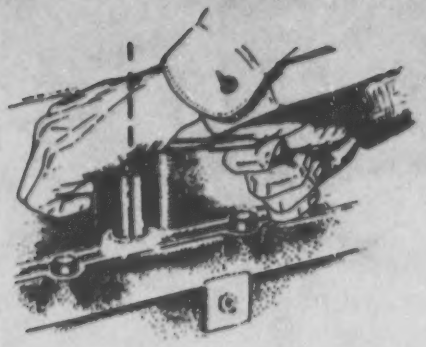


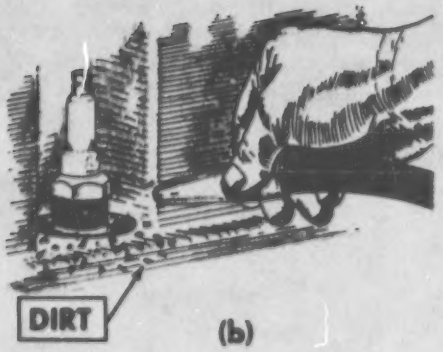

Figure 1. Grasp metal connectors rather than wire insulation when removing spark-plug wires. This helps prevent loosening the connectors from the wire ends.

Courtesy of the American Association for Vocational Instructional Materials

3. Loosen spark plug and blow debris away from plug with an air hose.
4. Remove spark plug from engine.



(a)




(b)

Figure 2. (a) Hold socket wrench straight while loosening plugs. (b) Remove dirt from around plugs before they are completely removed.

Courtesy of the American Association for Vocational Instructional Materials

5. Visually inspect for broken or damaged parts and for condition of electrode and terminal. Replace if defective.

6. Clean the spark plug.

Figure 3. Clean spark-plug threads with a wire brush.
Courtesy of the American Association for Vocational Instructional Materials

Figure 4. Remove oil film from spark plugs with a petroleum solvent.

Courtesy of the American Association for Vocational Instructional Materials

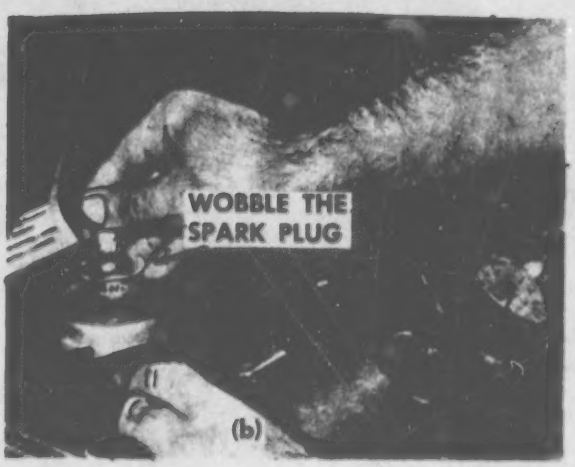



Figure 5. Clean spark plugs using a sand-blast type of cleaner.

Courtesy of the American Association for Vocational Instructional Materials

7. Adjust spark plug gap using wire gauge.
8. Reinstall plug and gasket. Start plug by hand; then torque to manufacturer's tightness specification.
9. Reinstall spark plug wire.

**STUDENT SELF-CHECK**
*DO NOT WRITE ON THIS PAGE!*
SERVICING SPARK PLUGS

Answer the following questions True or False.

1. The spark plug ignites the fuel-air mixture in the combustion chamber.
2. Spark plugs never wear out and never have to be replaced.
3. To gap a spark plug, bend the center electrode until the spark gap gauge fits snugly.
4. Badly fouled plugs should be replaced.
5. The first sign of failing plugs is engine misfire.

Compare your answers with the correct responses on this page. Review any incorrect answers before going on to the next Learning Activity.

**CORRECT RESPONSES**

1. True
2. False
3. False - never bend center electrode
4. True
5. True

**CHECK-OUT ACTIVITIES**

The statement below explains the activity you must be able to perform in order to complete this learning activity package. As you go through each activity, your instructor will rate your performance using the Instructor's Final Checklist, SERVICING SPARK PLUGS.

Clean and service a spark plug.

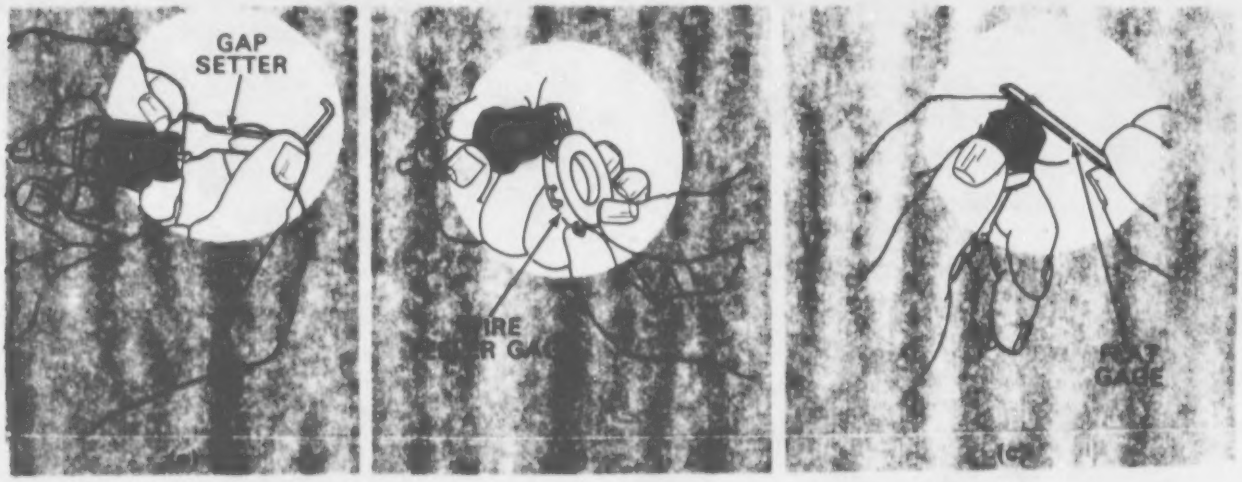



**Figure 6. (a) A gap setter is used to bend the ground electrode for adjusting the gap. (b) A wire feeler gage tends to follow the round contour that may remain after filing the electrodes. (c) A flat gage bridges rounded surfaces, thus resulting in a gap that is too wide.**

Courtesy of the American Association for Vocational Instructional Materials

DO NOT WRITE ON THIS PAGE

LAP TM–13

Student _____

Date _____

## SERVICING SPARK PLUGS

### Instructor's Final Checklist

Check the student's performance in the following elements of servicing spark plugs.

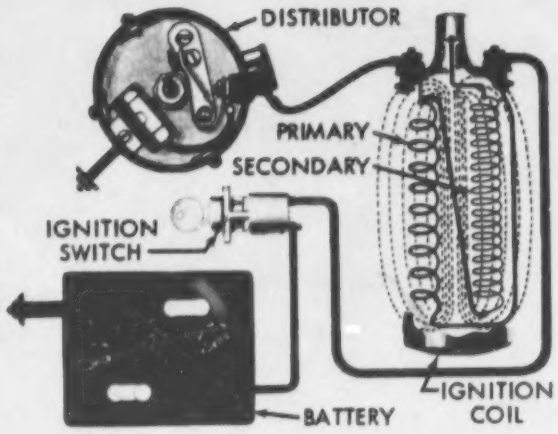
Place an X in the appropriate box indicating not accomplished, partially accomplished, or fully accomplished. If, because of special circumstances, the item was impossible to complete, place an X in the "Not Applicable" box.

Performance Level: All items must receive a rating of FULLY ACCOMPLISHED (or Not Applicable). If any items are rated Not Accomplished or Partially Accomplished, the student and instructor will discuss this and decide which learning activities must be repeated.

| | Student Performance | | | |
|---|---|---|---|---|
| | Not Applicable | Not Accomplished | Partially Accomplished | Fully Accomplished |
| In servicing spark plugs, the student: | | | | |
| 1. checked manufacturer's service manual for proper gap setting | [ ] | [ ] | [ ] | [ ] |
| 2. removed spark plug wire | [ ] | [ ] | [ ] | [ ] |
| 3. loosened plug and blew debris away with air hose | [ ] | [ ] | [ ] | [ ] |
| 4. inspected plug for broken or damaged parts and for condition of electrode; replaced if defective | [ ] | [ ] | [ ] | [ ] |
| 5. cleaned plug | [ ] | [ ] | [ ] | [ ] |
| 6. adjusted spark plug gap | [ ] | [ ] | [ ] | [ ] |
| 7. reinstalled plug; started plug by hand and torqued to manufacturer's specifications | [ ] | [ ] | [ ] | [ ] |
| 8. reinstalled spark plug wire | [ ] | [ ] | [ ] | [ ] |

# Learning Activity Package Number 14

Objective 40




Courtesy of the American Association for Vocational Instructional Materials

## SERVICING

## THE COIL

## Tractor Mechanics

### INTRODUCTION

Tractor operators seldom think of the coil as a cause of trouble, even though it is the high voltage source of the spark necessary for combustion in gasoline engines. A coil which is not functioning properly can cause several problems, including an engine which: (1) will not start; (2) is slow to start; (3) misfires occasionally; and (4) stops suddenly. In this learning activity package you will learn how to check, service, and replace the coil on a tractor.

### DIRECTIONS

Before you begin work on this learning activity package, be sure you have completed Learning Activity Package No. 12, "Servicing the Ignition Wires."

If you have completed this Learning Activity Package, read the objective below. If you feel you are already able to perform this task, read the Check-Out Activity on page 4 of this package. Then, either arrange with your instructor about doing the Check-Out Activity,

or

If you need to complete learning activities in order to be able to do the task, turn to p.2 and go through the Learning Activities in the order given.

### OBJECTIVE

Given an ignition coil, a coil tester, and the necessary tools and equipment, test and replace the coil on the designated tractor. The student's reading on the test indicator should be identical to the instructor's reading.

### LEARNING ACTIVITIES

1 READ the section on coils in *The Tractor Electrical System* (AAVIM), pp. 30-33.

(or) _____

2 READ *Fundamentals of Service: Electrical Systems* (John Deere Company), Chapter 6, "The Coil," pp. 6-3 through 6-6.

(or)_____

3 READ the section on coils in the manufacturer's service manual.

(or)_____

4 READ INSTRUCTIONS, SERVICING THE COIL.

(or)_____

5 CHECK your knowledge by taking Student Self-Check, Servicing the Coil.

(or)_____

6 PRACTICE testing and replacing the coil. Use Learning Activity 4 and the manufacturer's service manual.

7 ARRANGE with your instructor to complete this learning activity package by going through the CHECK-OUT ACTIVITIES listed on page 4.

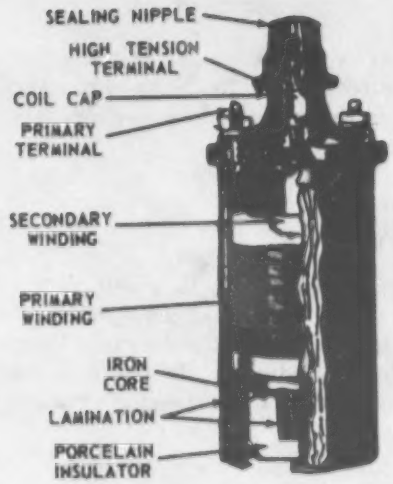



Figure 1. Cut away of an induction coil

Courtesy of John Deere and Company

## TOOLS AND EQUIPMENT NEEDED

1. Coil Tester

## MATERIALS AND SUPPLIES NEEDED

1. Ignition Coil

## SAFETY

No Special Safety Precautions

## INSTRUCTIONS

### SERVICING THE COIL*

To test and replace a coil, the following procedure should be used:

1. Remove wires from coil.
2. Connect suitable coil tester to input and output on coil. (NOTE: The following procedure steps, 3 through 9 are for an oscilloscope; if an oscilloscope is not available and an alternative method of testing must be used, three methods are described in *Fundamentals of Service: Electrical Systems*, pp. 6-3 through 6-6)
3. Select correct voltage on tester.
4. Rotate calibration knob to lowest level of power input.
5. Adjust pattern length on the oscilloscope until one full wave length is displayed.
6. Rotate calibration knob until a reading of 20 KV is reached; if 20 KV reading is reached with full display pattern, the coil is serviceable.
7. Check reasons for not reaching 20 KV reading, such as shorted open or reverse polarity.
8. If reverse polarity is noted, switch leads between plus (+) and minus (-) outlets on coil and recheck.
9. If shorted-open problems are noted, replace the coil.
10. Obtain the correct coil for the tractor and replace the coil using a screwdriver.

11. Recheck to get correct reading.

*The only service required is to keep the connections clean and tight. Dirt around the high voltage tower may cause "tracing" or leakage so it must be kept reasonably clean. There are no repairs to a cracked cap or to an internal failure; it must be replaced.

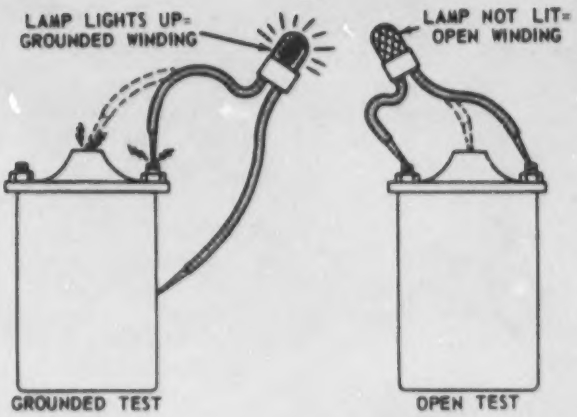



Figure 2. Testing Coil for Grounded or Open Windings

Courtesy of John Deere and Company

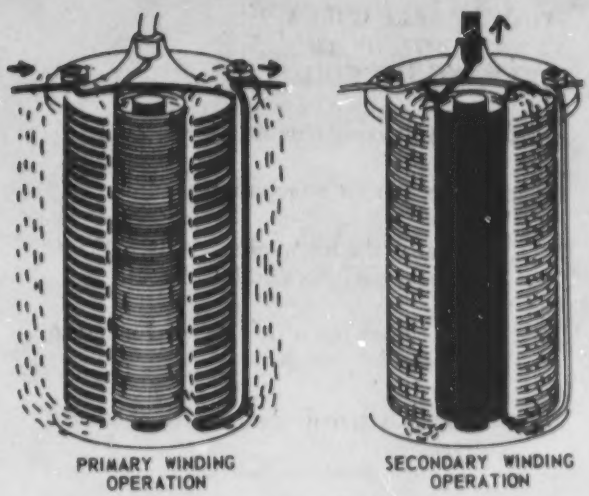



Figure 4. Operation of Coil

Courtesy of John Deere and Company

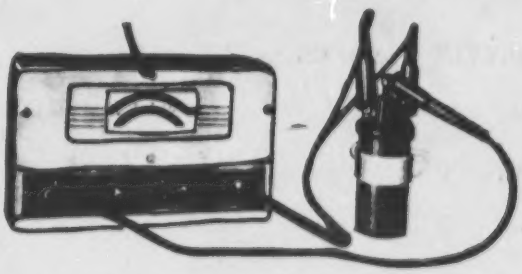


Figure 5. Meter-Type Coil Tester

Courtesy of John Deere and Company

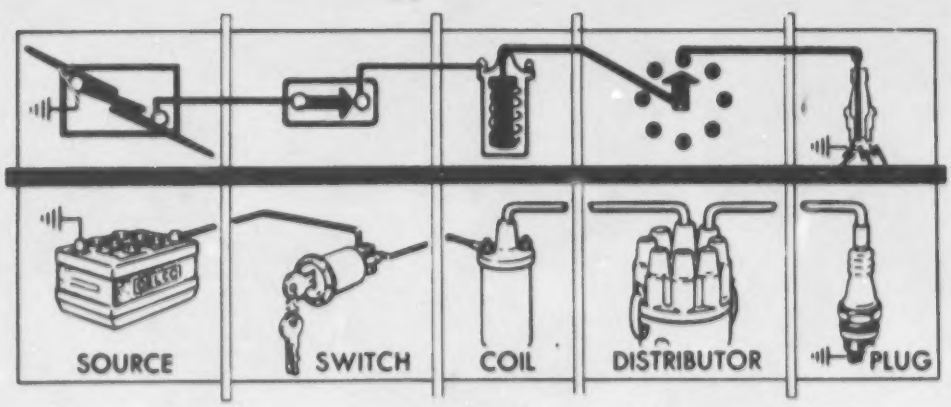



Figure 3. Components of an ignition circuit.

Courtesy of the American Association for Vocational Instructional Materials

**STUDENT SELF-CHECK**
*DO NOT WRITE ON THIS PAGE!*
**SERVICING THE COIL**

Answer the following true or false:

1. The coil cannot be repaired.
2. The coil is the high voltage source of the spark necessary for combustion.
3. Polarity does not affect the performance of the coil.
4. A coil is a transformer which increases voltage.

Compare your answers with the correct responses on this page. Review any incorrect answers before going on to the next Learning Activity.

**CORRECT RESPONSES**

1. True
2. True
3. False
4. True

**CHECK-OUT ACTIVITIES**

The statement below explains the activity you must be able to complete in order to finish this learning activity package. As you go through the activity, your instructor will rate your performance using the Instructor's Final Checklist, SERVICING THE COIL

Test and replace the ignition coil on the designated tractor.

DO NOT WRITE ON THIS PAGE

LAP TM–14

Student _____

Date _____

## SERVICING THE COIL

### Instructor's Final Checklist

Check the student's performance in the following elements of servicing the coil.

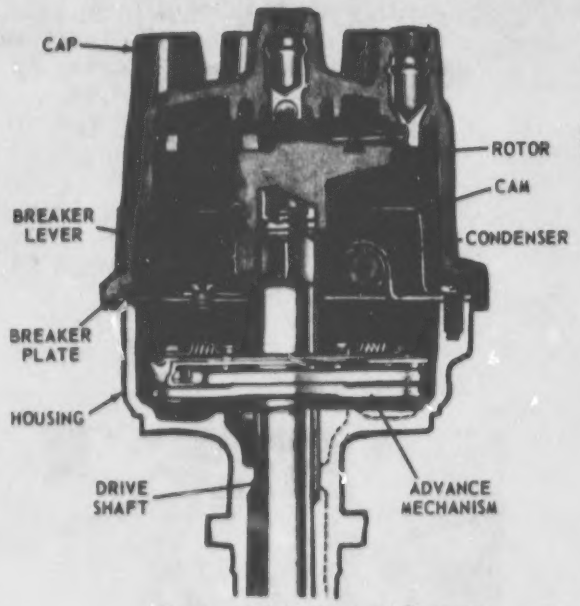
Place an X in the appropriate box indicating not accomplished, partially accomplished, or fully accomplished. If, because of special circumstances, the item was impossible to complete, place an X in the "Not Applicable" box.

Performance Level: All items must receive a rating of FULLY ACCOMPLISHED (or Not Applicable). If any items are rated Not Accomplished or Partially Accomplished, the student and instructor will discuss this and decide which learning activities must be repeated.

| | Student Performance | | | |
|---|---|---|---|---|
| | Not Applicable | Not Accomplished | Partially Accomplished | Fully Accomplished |
| In servicing the coil, the student: | | | | |
| 1. removed wires from coil | [ ] | [ ] | [ ] | [ ] |
| 2. connected suitable coil tester to input and output terminals | [ ] | [ ] | [ ] | [ ] |
| 3. checked coil for proper voltage as listed in the manufacturer's service manual | [ ] | [ ] | [ ] | [ ] |
| 4. obtained the proper coil for the tractor and replaced coil if it was defective | [ ] | [ ] | [ ] | [ ] |
| 5. rechecked coil to get proper reading | [ ] | [ ] | [ ] | [ ] |
| 6. reinstalled all ignition wiring and checked for proper operation | [ ] | [ ] | [ ] | [ ] |

# Learning Activity Package Number 15

Objectives 32-33-37-38-39-41




Courtesy of John Deere and Company

# SERVICING THE DISTRIBUTOR

# Tractor Mechanics

## INTRODUCTION

The proper functioning of the distributor is vital to the smooth, efficient operation of a gasoline engine. If the distributor is to perform correctly (i.e., deliver sparks to each cylinder at the instant the fuel is fully compressed by the piston), the parts must be in good condition and properly gapped. Too narrow a gap will cause rapid burning of points. Too wide a gap will produce a weak spark. In either case, the tuning will be affected and the engine will not run efficiently. In this learning activity package you will learn to properly service a distributor, to check the dwell, and to correctly set the timing with a timing light.

## DIRECTIONS

Read the objectives below. If you believe you are already able to perform these tasks, read the Check-Out Activities on page 7 of this package. Then, either arrange with your instructor about doing the Check-Out Activities,

or

If you need to complete learning activities in order to do these tasks, turn to page 2 and go through the Learning Activities in the order given.

## OBJECTIVES

1. Given a tractor with an ignition distributor and the necessary tools and equipment, check the condition of the distributor. Evaluation will be based on successful completion of all points on the Instructor's Final Checklist.

2. Given distributor points and condenser, service manual, feeler gauge, dwell meter, and ignition wrench set, replace the points and condenser on the designated tractor. Point gap setting should be 100% accurate as specified in the manufacturer's service manual.

3. Given a tractor with operational distributor, manufacturer's service manual, a feeler gauge, dwell meter, and ignition tools, set the breaker points to 100% accuracy as specified by the service manual.

4. Given an ignition distributor, service manual, and necessary tools, replace the ignition distributor on the designated tractor. Replacement should include the completion of all the steps on the Instructor's Final Checklist.

5. Given a tractor that is out of time, a service manual, a timing light and the necessary tools, set the ignition timing to 100% accuracy as specified in the service manual.

6. Given a tractor with distributor having an advance mechanism, a service manual, a timing light with advance adjusting mechanism, and the necessary tools and equipment, test the distributor advance mechanism. The results should be within three degrees of the specifications in the service manual.

## LEARNING ACTIVITIES

1 READ *Tractor Maintenance: Principles and Procedures* (AAVIM), pp. 89-102.

(or) _____

2 VIEW Slides Nos. 223-244, "Fundamentals of Service: Electrical Systems" (John Deere Company).

(or) _____

3 READ the section on distributors in the manufacturer's service manual.

(or) _____

4 READ INSTRUCTIONS A, SERVICING THE DISTRIBUTOR; B, USING THE DWELL METER AND TIMING LIGHT; and C, CHECKING THE DISTRIBUTOR ADVANCE MECHANISM.

(or) _____

5 CHECK your knowledge of the distributor by taking Student Self-Check, Servicing the Distributor.

6 PRACTICE removing and checking the condition of the distributor, replacing points, using a wire gauge to gap points, checking dwell by use of a meter, and timing an engine using a timing light. Follow the procedure outlined in Learning Activity 4 and the manufacturer's service manual.

7 ARRANGE with your instructor to complete this learning activity package by going through the CHECK-OUT ACTIVITIES listed on page 7.

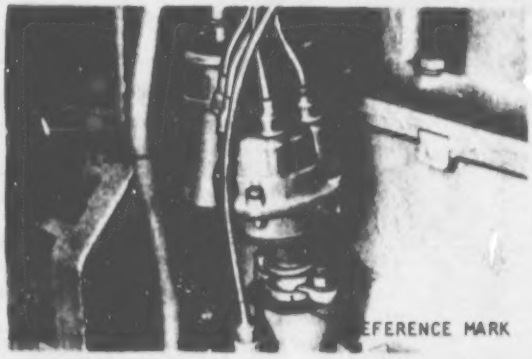



**Figure 1. Ignition Distributor**

Courtesy of John Deere and Company

## TOOLS AND EQUIPMENT NEEDED

1. Power Timing Light
2. Dwell Meter
3. Ignition Wrench Set
4. Feeler Gauge
5. I & T Manual

## MATERIALS AND SUPPLIES NEEDED

1. Cleaning Solvent
2. Cleaning Brush
3. Breaker Points
4. Condensor
5. Oil – SAE 10-W

## SAFETY

1. Watch for fan blades when timing the engine.

## INSTRUCTIONS

### A. SERVICING THE DISTRIBUTOR

In testing the condition of the distributor, the following procedure should be used:

1. Remove dirt from outside surface of distributor and cap.
2. Remove cap and clean inner surfaces; leave wires connected.
3. Check distributor cap for chips, breaks, or cracks. Replace if defective.
4. Remove and clean distributor arm (rotor).
5. Remove dust cover, if one is used, and check condition of felt seal.

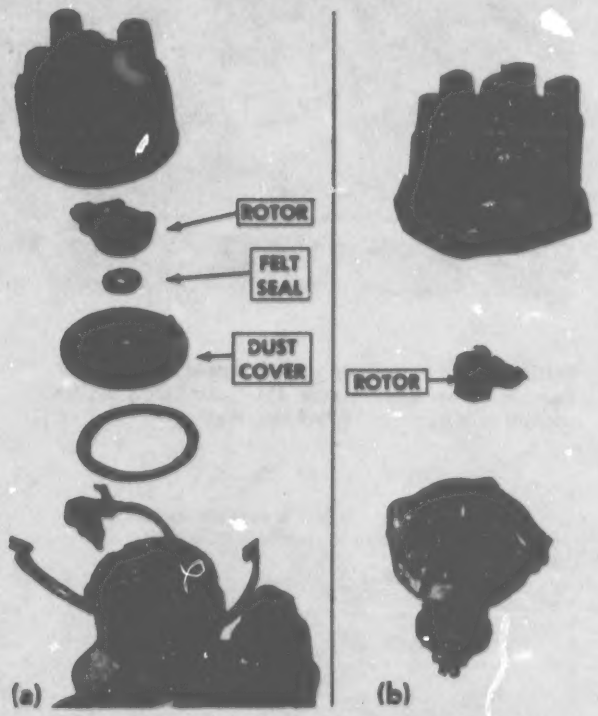



Figure 2 (a) Check the condition of the rotor, felt seal and dust cover. (b) Magnetic-pulse type distributor used on factory-installed transistorized ignition systems.

Courtesy of the American Association for Vocational Instructional Materials

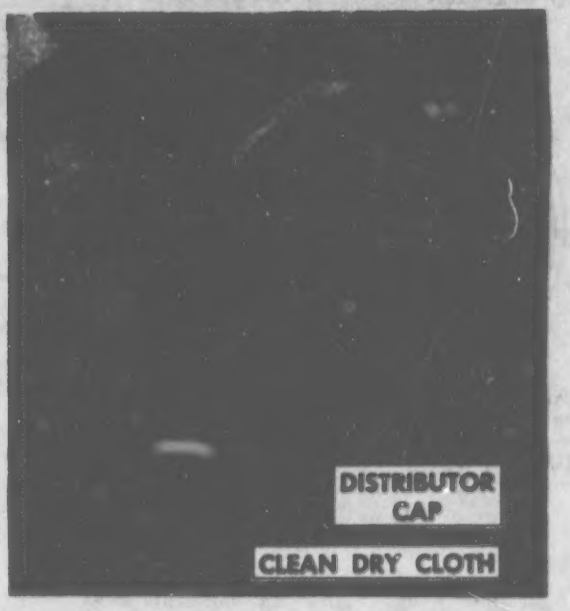



Figure 3 Clean the inner surface of the distributor cap with a clean dry cloth.

Courtesy of the American Association for Vocational Instructional Materials

In replacing the ignition points and condenser, the following procedure should be used:

1. Refer to manufacturer's service manual for specifications.
2. Remove breaker arm and spring.
3. Remove stationary breaker point bracket.
4. Clean and then lubricate cam with petroleum jelly or multi-purpose grease.
5. Replace condenser.
6. Install new points in reverse order of the procedure used to disassemble.
7. Set breaker points using a feeler gauge; check with dwell meter.

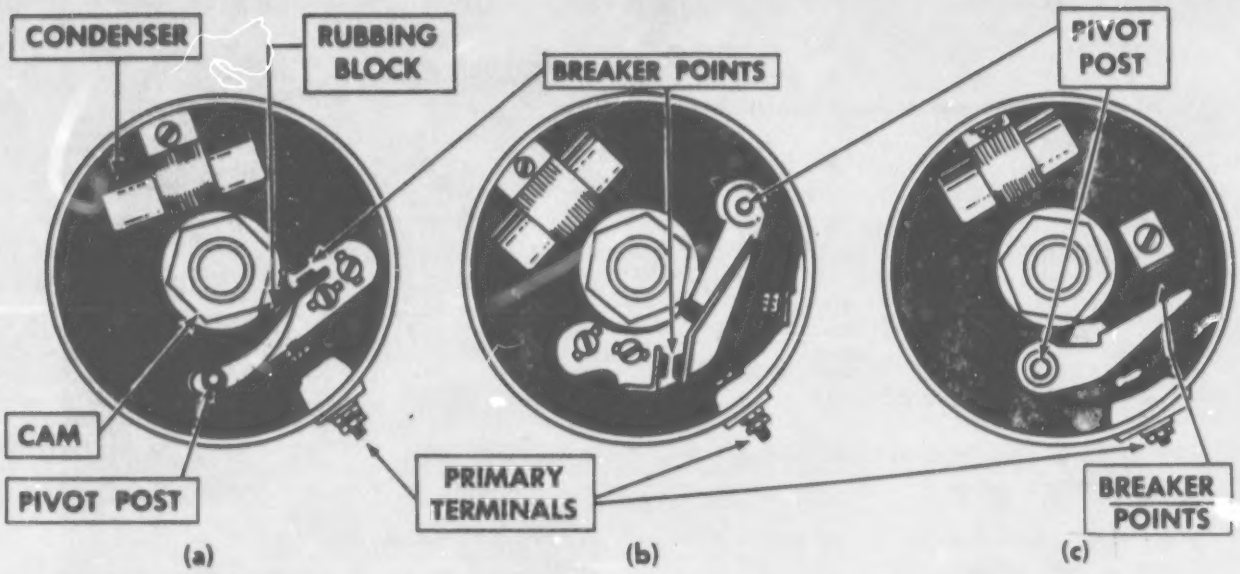



**Figure 4** Typical mounting arrangements for movable breaker arms on different makes of distributors. Breaker arm is removed by loosening spring connection at primary terminal and lifting arm from pivot post.

Courtesy of the American Association for Vocational Instructional Materials

## INSTRUCTIONS

### B. USING THE DWELL METER AND TIMING LIGHT

In using the dwell meter to check accuracy of the point gap setting, the following procedure should be used:

1. Refer to manufacturer's service manual for proper specifications.
2. Turn engine until cam opens breaker points to widest position.
3. Check points for proper spacing, using a feeler gauge.
4. If adjustment is necessary, loosen lock screw on bracket.
5. Adjust points for proper spacing and alignment and tighten lock screw on bracket.
6. Recheck gap between points and wipe clean by running a strip of clean cloth or paper between the contacts.

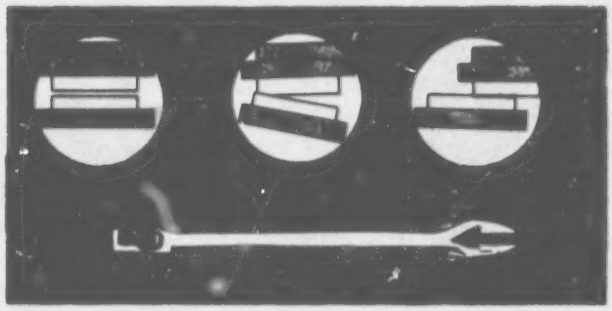


**FIGURE 5** (a) Breaker points should fit together squarely to keep down wear. (b) and (c) Only partial contact causes arcing and uneven wear.

Courtesy of the American Association for Vocational Instructional Materials

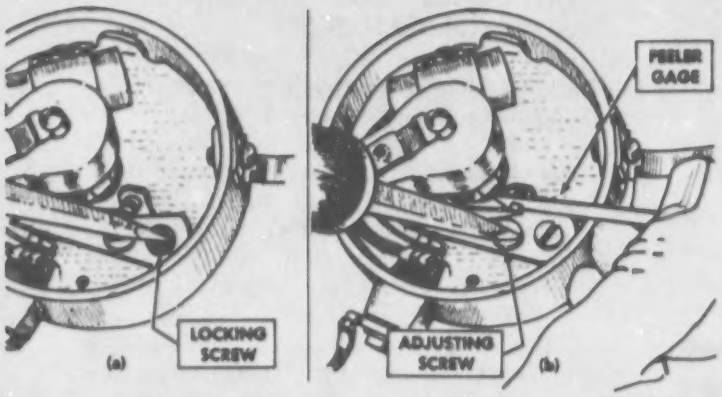



Figure 6. To adjust breaker points, (a) loosen lock screw on bracket and (b) adjust points with adjusting screw.

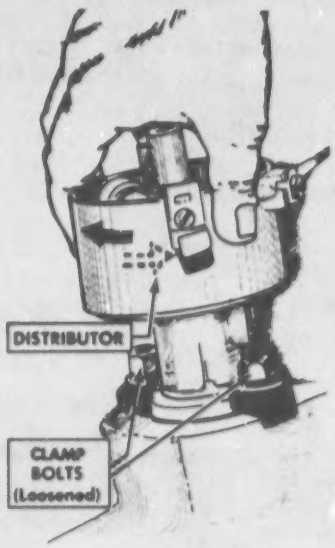



Figure 7. Rotate the distributor body in the direction the rotor turns until points close and then in the opposite direction until points start to open.

Courtesy of the American Association for Vocational Instructional Materials

7. Check and make final adjustments using the dwell meter:
   a. Connect dwell meter lead to primary circuit.
   b. Connect dwell meter lead to ground.
   c. Start engine.
   d. Read dwell; make proper adjustments. (If external adjustment is not available, regap points internally to correct dwell.)

In using the timing light to set ignition timing, the following procedure should be used:

1. Check manufacturer's service manual for proper specifications.
2. Locate timing marks on flywheel or fan pulley.
3. Connect timing light as recommended by manufacturer.
4. Determine from service manual what timing mark to use with light and set engine at correct RPM.
5. Chalk the timing mark so it is easily seen.
6. Start engine and run at speed recommended in service manual.
7. Direct timing light at markings on flywheel or on fan pulley.
8. Loosen clamps that hold distributor.

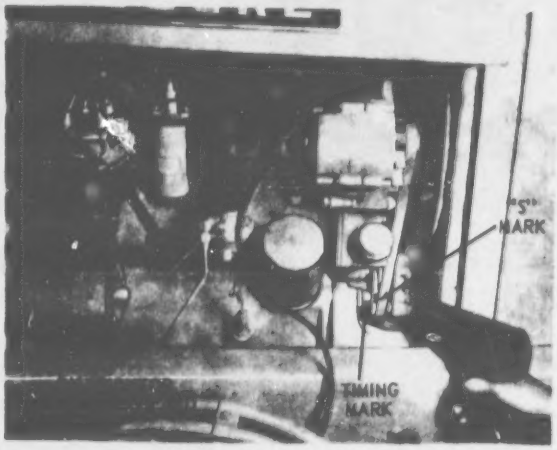
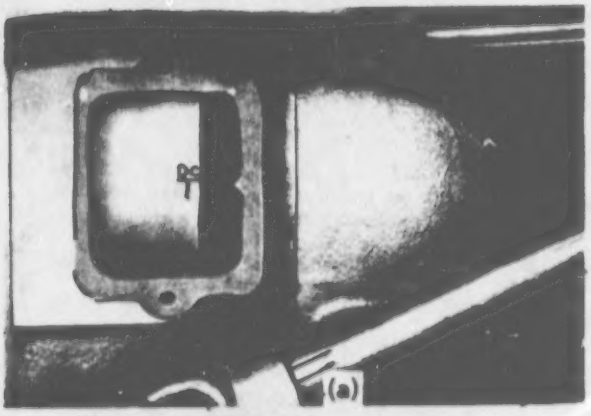



Figure 8. Timing the Distributor with a Timing Light

Courtesy of John Deere and Company

9. Turn distributor body slightly until timing mark is opposite the pointer.
10. Tighten distributor.
11. Recheck timing after tightening.
12. Remove timing light.
13. Replace cover over timing hole if removed.



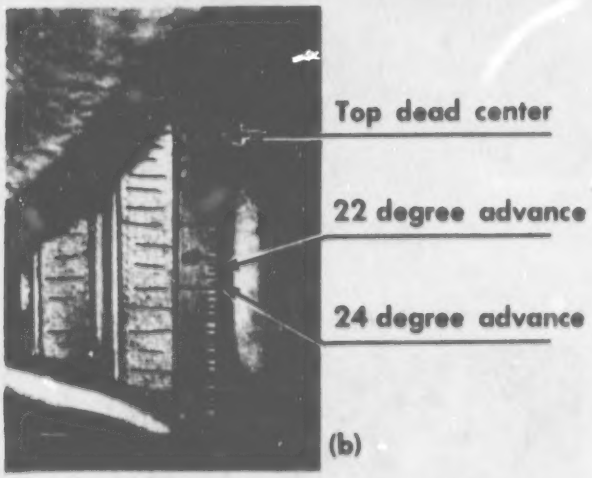




Figure 9. (a) One type of FLYWHEEL MARKING indicating top dead center position on No. 1 cylinder. (b) Markings on FAN-BELT DRIVE PULLEY indicating top dead center and various advance positions.

Courtesy of the American Association for Vocational Instructional Materials

## INSTRUCTIONS

### C. CHECKING THE DISTRIBUTOR ADVANCE MECHANISM

In testing the distributor advance mechanism, the following procedure should be used:

1. Check manufacturer's service manual for initial timing, RPM at initial timing, RPM at mechanical advance, vacuum advance degrees, RPM at vacuum advance beginning, and high RPM total advance.
2. Connect timing light according to manufacturer's specification; disconnect and plug vacuum advance hose line.
3. Start engine and adjust engine RPM to low idle.
4. Check initial timing with timing light, and advance the unit on the timing light; set at zero.
5. Adjust initial timing to correct specifications.
6. Bring engine to RPM of full mechanical advance. Rotate timing advance mechanism in timing light until original timing marks are together. Read mechanical advance on timing light dial.

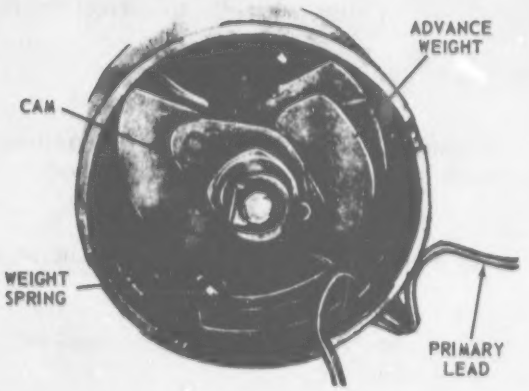



Figure 10. Centrifugal Advance Machanisms

Courtesy of John Deere and Company



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7. Connect vacuum advance to distributor.
8. Bring engine RPM to high idle.
9. Rotate timing light advance dial until original marks are together.
10. Read degrees of total advance on dial and compare with manufacturer's specifications.

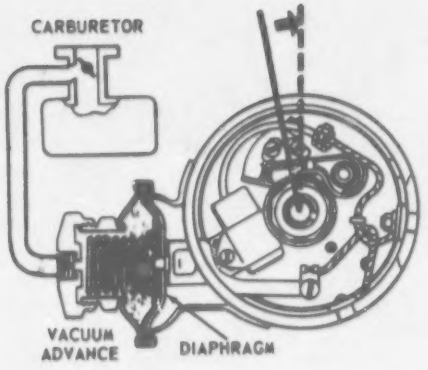



Figure 11. Vacuum Advance Mechanism

Courtesy of John Deere and Company

In removing and replacing the distributor, the following procedure should be used:

1. Remove primary and secondary ignition wires from distributor.
2. Check and mark position of rotor.
3. Loosen mounting bolts and remove distributor.
4. Install new distributor. Rotor must be in the same position as it was in the old distributor.
5. Reconnect primary and secondary ignition wires.
6. Set ignition timing using a timing light.
7. Set breaker points using a dwell meter.

STUDENT SELF-CHECK
*DO NOT WRITE ON THIS PAGE!*
SERVICING THE DISTRIBUTOR

1. The distributor does three things. Can you list them?
2. A point gap set too wide produces a _____ spark.
3. Which of the following can be caused by improper timing?

   a. knocking; b. backfiring; c. warped valves; d. loss of power; e. damage to engine parts.

4. List two methods that can be used to time an engine. Which is the best?

Compare your answers with the correct responses on the following page. Review any incorrect answers before going on to the next Learning Activity.

CHECK-OUT ACTIVITIES

The statements below explain the activities you must be able to complete in order to finish this learning activity package. As you go through each activity, your instructor will rate your performance using the Instructor's Final Checklist, SERVICING THE DISTRIBUTOR.

On the designated tractor:

Check the condition of the distributor.

Replace the distributor points and condenser.

Set the breaker points.

Set the ignition timing.

Test the distributor advance mechanism.

Replace the ignition distributor.

**CORRECT RESPONSES**

1. a - Opens and closes the primary circuit; b - Times the high voltage surges; c - Directs current to the proper spark plug.

2. Weak

3. All of them

4. Breaker-point method, timing light method. The timing light method is the best.

DO NOT WRITE ON THIS PAGE

LAP 7M–15

Student _____

Date _____

## SERVICING THE DISTRIBUTOR

### Instructor's Final Checklist

Check the student's performance in the following elements of servicing the distributor.

Place an X in the appropriate box indicating not accomplished, partially accomplished, or fully accomplished. If, because of special circumstances, the item was impossible to complete, place an X in the "Not Applicable" box.

Performance Level: All items must receive a rating of FULLY ACCOMPLISHED (or Not Applicable). If any items are rated Not Accomplished or Partially Accomplished, the student and instructor will discuss this and decide which learning activities must be repeated.

| | | Student Performance | | | |
|---|---|---|---|---|---|
| | | Not Applicable | Not Accomplished | Partially Accomplished | Fully Accomplished |
| 1. | In servicing an ignition distributor, the student: | | | | |
| | a. removed dirt from the outside surface of distributor and cap | [ ] | [ ] | [ ] | [ ] |
| | b. cleaned inner surface | [ ] | [ ] | [ ] | [ ] |
| | c. identified defective cap (chips, breaks, cracks) and replaced | [ ] | [ ] | [ ] | [ ] |
| | d. cleaned the rotor arm | [ ] | [ ] | [ ] | [ ] |
| | e. checked the dust cover | [ ] | [ ] | [ ] | [ ] |
| 2. | In replacing the ignition distributor, the student: | | | | |
| | a. removed the primary and secondary ignition wires from the distributor | [ ] | [ ] | [ ] | [ ] |
| | b. noted the position of the rotor | [ ] | [ ] | [ ] | [ ] |
| | c. loosened bolts and removed old distributor | [ ] | [ ] | [ ] | [ ] |
| | d. installed a new distributor | [ ] | [ ] | [ ] | [ ] |
| | e. reconnected primary and secondary ignition wires | [ ] | [ ] | [ ] | [ ] |
| | f. set breaker points to specifications | [ ] | [ ] | [ ] | [ ] |
| | g. set ignition timing to specifications | [ ] | [ ] | [ ] | [ ] |

DO NOT WRITE ON THIS PAGE

LAP TM–15

Student _____

Date _____

## SERVICING THE DISTRIBUTOR

### Instructor's Final Checklist (Continued)

Check the student's performance in the following elements of servicing the distributor.

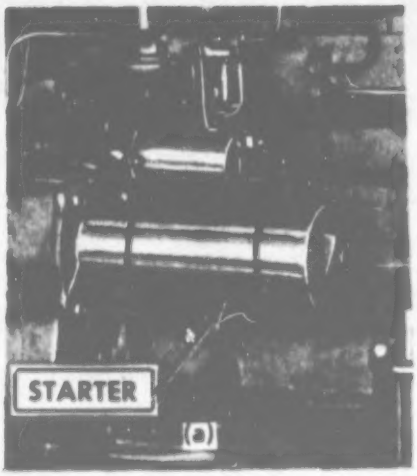
Place an X in the appropriate box indicating not accomplished, partially accomplished, or fully accomplished. If, because of special circumstances, the item was impossible to complete, place an X in the "Not Applicable" box.

Performance Level: All items must receive a rating of FULLY ACCOMPLISHED (or Not Applicable). If any items are rated Not Accomplished or Partially Accomplished, the student and instructor will discuss this and decide which learning activities must be repeated.

| | Student Performance | | | |
|---|---|---|---|---|
| | Not Applicable | Not Accomplished | Partially Accomplished | Fully Accomplished |
| h. adjusted the distributor advance mechanism to within three degrees of specifications | [ ] | [ ] | [ ] | [ ] |

# Learning Activity Package Number 16

Objectives 65-66-67-68




Courtesy of the American Association for Vocational Instructional Materials

# TESTING THE STARTING CIRCUIT

# Tractor Mechanics

## INTRODUCTION

The starting system of a farm tractor has four basic parts: (1) a source of energy (Usually a battery), (2) a switch which activates the ignition circuit (key switch), (3) a starter motor switch (solenoid), and (4) the starting motor. Batteries and key switches are relatively simple and are easily understood. But the starting motor and the solenoid are more complex. In this learning activity package you will learn how to test and repair all four parts of the starting system on tractors.

## DIRECTIONS

Read the objectives below. If you believe you are already able to perform these tasks, read the Check-Out Activities on page 6 of this package. Then, either arrange with your instructor about doing the Check-Out Activities,

or,

If you need to complete learning activities in order to do these tasks, turn to page 2 and go through the Learning Activities in the order given.

## OBJECTIVES

1. Given a set of screwdrivers, pliers, ignition wrenches, and a continuity tester or ohmmeter, check an ignition switch on the designated tractor. The continuity-tester readings should agree with those of the instructor.

2. Given a set of screwdrivers, pliers, ignition wrenches, and a continuity tester or ohmmeter, check the safety switch on the designated tractor. The reading on the continuity tester or ohmmeter should agree with the instructor's reading.

3. Given a set of ignition wrenches, an open-end wrench set, a D.C. voltmeter or a multi-meter, check a solenoid on the designated tractor. The voltmeter reading should agree with the instructor's reading.

4. Using a mechanic's tool set, an armature tester (growler), a continuity tester, voltmeter, ammeter and tachometer (speed indicator), check the armature and fields of the starter on the designated tractor. All check-out procedures on an instructor's checklist will be completed.

## LEARNING ACTIVITIES

1 READ *The Tractor Electrical System* (AAVIM), pp. 25-30.

(or)

2 READ *Fundamentals of Service: Electrical Systems* (John Deere Company), Chapter 5, "Starting Circuits," pp. 5-19 through 5-33.

(or)

3 READ INSTRUCTIONS A, CHECKING SWITCHES, and INSTRUCTIONS B, CHECKING STARTER ARMATURE AND FIELDS.

4 CHECK YOUR KNOWLEDGE of the starting circuit by taking Student Self-Check, TESTING THE CRANKING CIRCUIT .

(or)

5 ASK YOUR INSTRUCTOR to show you how to use the multi-meter if you have not used it before.

(or)

6 PRACTICE checking the starting switch, safety switch, solenoid, armature, and field of your starting circuit. Follow the procedure outlined in Learning Activity 4 and in the manufacturer's service manual.

7 ARRANGE with your instructor to complete this learning activity package by going through the CHECK-OUT ACTIVITIES listed on page 6.

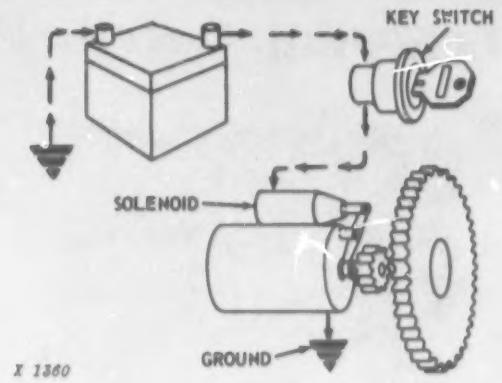



**Figure 1. Starting Circuit in Operation: 1) As the Starter Switch is Activated**
Courtesy of John Deere and Company

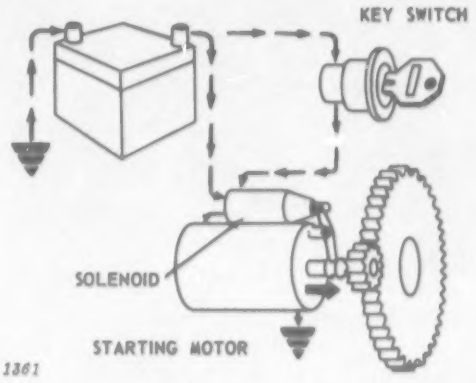



**Figure 2. Starting Circuit in Operation: 2) Starting Motor Engages Flywheel**
Courtesy of John Deere and Company

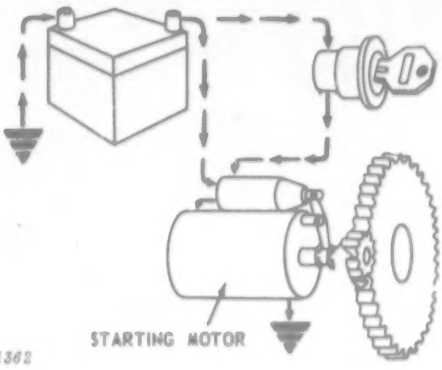



**Figure 3. Starting Circuit in Operation: 3) Starting Motor Cranks Engine**
Courtesy of John Deere and Company

## TOOLS AND EQUIPMENT NEEDED

1. Mechanics Tool Set
2. Ignition Wrenches
3. Continuity Tester or Ohmmeter
4. D.C. Voltmeter or Multi-Meter
5. Armature Tester
6. Ammeter
7. Tachometer

## MATERIALS AND SUPPLIES NEEDED

1. 00 Sandpaper

## SAFETY

1. Remove watches prior to conducting growler test.
2. Keep anyone with heart "pacemaker" clear of the area when conducting growler test.

## INSTRUCTIONS

### A. CHECKING SWITCHES

In checking the ignition switch, the following procedure should be used:

1. Disconnect all wires from switch (noting their position so they can be reconnected).
2. Attach continuity tester across *Battery* and *Ignition* terminals of the ignition switch.
3. Turn switch to *Start* and check for contact. Shake switch to check for shorts.
4. Attach continuity tester across *Battery* and *Start* terminals of the switch.
5. Turn switch to *Start* and check for contact.
6. Remove continuity tester and reconnect wires to switch or replace ignition switch if faulty.

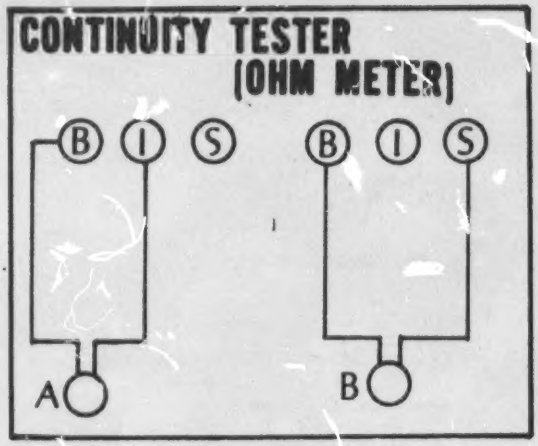



Figure 4 Testing Battery Ignition Circuit B) Testing Battery-Starter Circuit

In checking the safety switch, the following procedure should be used:

1. Disconnect wires from safety switch.
2. Attach continuity tester across switch terminals.
3. Activate switch and check for contact. If there is continuity, the safety switch is shorted.
4. Remove continuity tester and reconnect wires to safety switch.
5. Replace safety switch if it is faulty.

In checking the solenoid, the following procedure should be used:

1. Disconnect solenoid-to-starter cable at the solenoid.
2. Connect voltmeter from starter terminal of the solenoid to ground.
3. Activate starter switch and observe reading on voltmeter for battery voltage.
4. Remove voltmeter and reconnect starter cable.

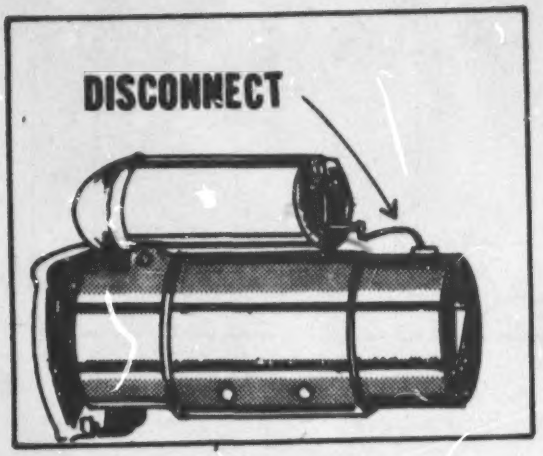



Figure 5. Disconnect Solenoid from Starter at Solenoid

INSTRUCTIONS

B. CHECKING STARTER ARMATURE AND FIELDS

In testing the armature for grounds, shorts, and balance, the following procedure should be used:

1. Ground test: Put armature in growler jaws and turn power switch to *test* position. Touch one test lead to the armature core and touch the other lead to each commutator bar one at a time. Observe the test light. If the test lamp glows on any bar, the armature is grounded and has to be replaced.

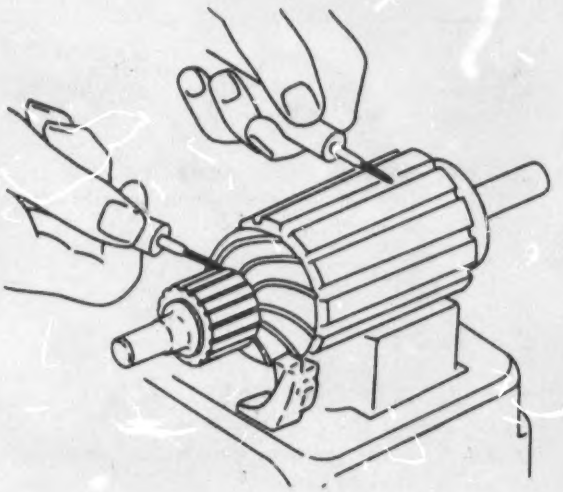


Figure 6. Testing Armature for Grounds

Courtesy of John Deere and Company

2. Short test: Put armature in growler jaws and turn power switch to *growler* position. Hold a steel blade parallel with, and touching, the armature core. Rotate the armature slowly one or more revolutions in the growler jaw. If the steel blade vibrates on any position of the core, then the area is shorted and the armature must be replaced.

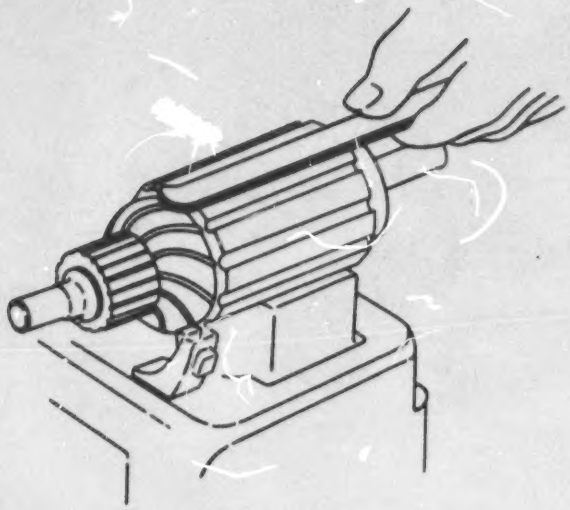


Figure 7. Testing Armature for Short Circuits

Courtesy of John Deere and Company

3. Balance test: Put armature in growler jaws and turn power switch to *growler* position. Put contact fingers of meter test cable across adjacent commutator bars at the side of the commutator and adjust voltage control until the needle is at the highest reading on the scale. Next test each commutator bar with the adjacent bar until all bars have been checked. (Note: A reading of zero indicates an open circuit.)

In testing the field, the following procedure should be used:

1. Put the brushes aside so that they do not touch any part of the starter.

2. Remove the screw that attaches the solenoid point assembly brush head to the frame.

3. Insert a piece of paper between the solenoid points.

4. Connect one test prod to the terminal screw and one prod to the starter frame. If test lamp lights, the field windings are shorted and must be replaced.

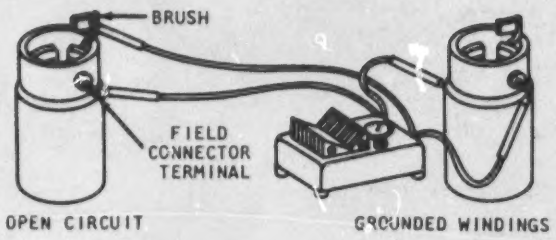



Figure 8. Testing Field Windings

Courtesy of John Deere and Company

## STUDENT SELF-CHECK
*DO NOT WRITE ON THIS PAGE!*
## TESTING THE CRANKING CIRCUIT

1. In the cranking circuit the _____ supplies energy to the starter.

2. The solenoid switch is on the outside of the starter-motor housing. (T or F)

3. Starter motor brushes should be replaced when they are worn to _____ the original length.

4. _____ should be used in cleaning a commutator.

5. The starting motor should never be run for more than _____ without resting it for a few minutes.

6. When replacing starter brushes, always use a matched set of brushes. (T or F)

7. The three tests used for armature testing are a. _____ b. _____ and c. _____.

Compare your answers with the correct responses on the following page. Review any incorrect answers before going on to the next Learning Activity.

## CORRECT RESPONSES

1. Battery
2. True
3. 1/2
4. 00 Sandpaper
5. 30 Seconds
6. True
7. a. ground test
   b. short test
   c. balance test

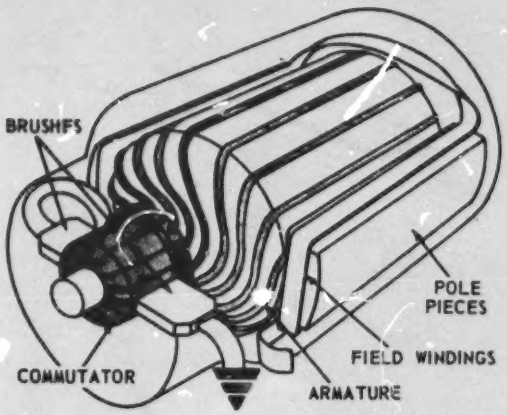



Figure 10. Armature and Brushes in Starting Motor

Courtesy of John Deere and Company

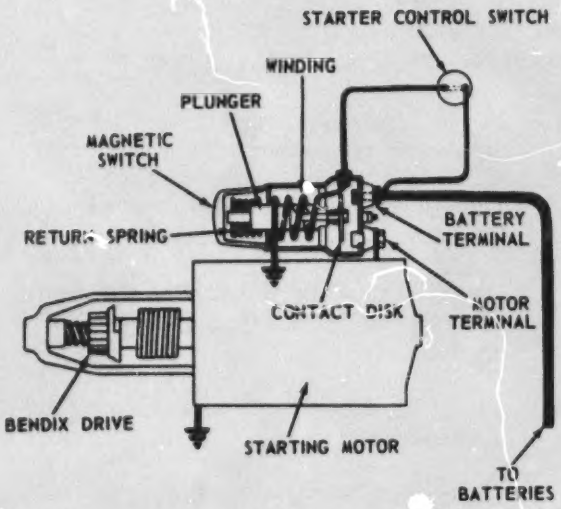



Figure 9. A Typical Magnetic Switch Circuit

Courtesy of John Deere and Company

## CHECK-OUT ACTIVITIES

The statements below explain the activities you must be able to complete in order to finish this learning activity package. As you go through each activity, your instructor will rate your performance using the Instructor's Final Checklist, TESTING THE STARTING CIRCUIT.

On the designated tractor:

Check an ignition switch.

Check the safety switch.

Check the solenoid.

Check the armature and fields of the starter.

DO NOT WRITE ON THIS PAGE

LAP TM–16

Student _____

Date _____

## TESTING THE STARTING CIRCUIT

### Instructor's Final Checklist

Check the student's performance in the following elements of testing the starting circuit.

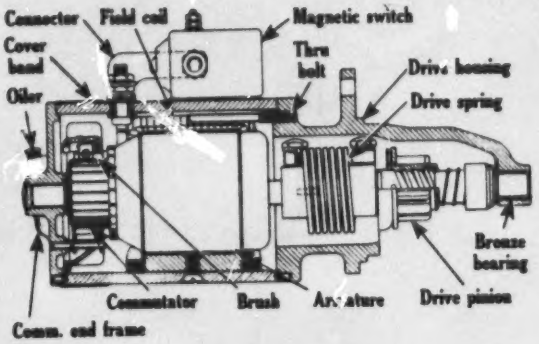
Place an X in the appropriate box indicating not accomplished, partially accomplished, or fully accomplished. If, because of special circumstances, the item was impossible to complete, place an X in the "Not Applicable" box.

Performance Level: All items must receive a rating of FULLY ACCOMPLISHED (or Not Applicable). If any items are rated Not Accomplished or Partially Accomplished, the student and instructor will discuss this and decide which learning activities must be repeated.

| | Student Performance | | | |
|---|---|---|---|---|
| | Not Applicable | Not Accomplished | Partially Accomplished | Fully Accomplished |
| In testing the starting circuit, the student: | | | | |
| 1. disconnected all wires from the ignition switch and noted their position | [ ] | [ ] | [ ] | [ ] |
| 2. checked the switch for shorts, using the continuity tester | [ ] | [ ] | [ ] | [ ] |
| 3. checked the switch for contact, using the continuity tester | [ ] | [ ] | [ ] | [ ] |
| 4. reinstalled the switch and checked for proper operation | [ ] | [ ] | [ ] | [ ] |
| 5. checked the safety switch, using the same procedure as used with the ignition switch | [ ] | [ ] | [ ] | [ ] |
| 6. checked the solenoid using the outline on Instruction Sheet I | [ ] | [ ] | [ ] | [ ] |
| 7. removed the starter | [ ] | [ ] | [ ] | [ ] |
| 8. completed the ground test | [ ] | [ ] | [ ] | [ ] |
| 9. completed a short test | [ ] | [ ] | [ ] | [ ] |
| 10. completed a balance test | [ ] | [ ] | [ ] | [ ] |
| 11. tested the field | [ ] | [ ] | [ ] | [ ] |
| 12. reinstalled the starter | [ ] | [ ] | [ ] | [ ] |
| 13. checked for proper operation | [ ] | [ ] | [ ] | [ ] |

# Learning Activity Package Number 17

Objectives 69-71-72-73




Courtesy of the American Association for Vocational Instructional Materials

# SERVICING THE STARTER MOTOR

## Tractor Mechanics

### INTRODUCTION

The starter is an electric motor constructed so that it can turn the flywheel of the engine and start the tractor. It will be located either on the side or on top of the tractor flywheel housing. The starter should crank the engine in less than 30 seconds; it will become overheated and damaged if turned longer. In this learning activity package you will learn how to remove, dismantle, repair, and replace the starting motor on a tractor.

### DIRECTIONS

Before you start to work on this learning activity package, be sure you have completed learning activity package 16, *Testing the Starting Circuit.*

If you have completed this Learning Activity Package, read the objectives below. If you feel you are already able to perform these tasks, read the Check-Out Activities on page 6 of this package. Then, either arrange with your instructor about doing the Check-Out Activities,

or

If you need to complete learning activities in order to be able to do these tasks, turn to page 2 and go through the Learning Activities in the order given.

### OBJECTIVES

1. Given an open-end and a box-end wrench set, screwdrivers, bushing puller and driver set, an adjustable reamer, and specified bearing lubricant, replace the bearings on the designated starter. The bushings will be installed without damage to other parts and the starter will function properly.

2. Using the designated engine, a mechanic's tool set, an inch/pound torque wrench and new starter brushes, replace the starter brushes. There will be no damage to any parts; all parts will be torqued to specifications; and the starter will operate when current is supplied.

3. Given a new starter drive and a tool set, replace the starter drive on the designated tractor. All steps on the Instructor's Check Sheet must be completed acceptably.

4. Given the necessary replacement parts, a manufacturer's service manual, and mechanic tool set, replace a starter motor solenoid. The disassembly and reassembly order will follow the steps outlined in the service manual. There will be no damage to any parts and the solenoid will operate according to the manufacturer's service manual.

## LEARNING ACTIVITIES

1 READ *Fundamentals of Service: Electrical Systems* (John Deere Company), pp. 5-21 through 5-33 (selective parts).

(or) _____

2 READ *Tractor Maintenance: Principles and Procedures* (AAVIM) pp. 104-107.

(or) _____

3 CHECK YOUR KNOWLEDGE of starters by taking Student Self-Check, SERVICING A STARTER.

(or) _____

4 READ INSTRUCTIONS A, SERVICING THE BEARING, BUSHING, AND DRIVES and INSTRUCTIONS B, REPLACING THE SOLENOID.

5 READ the section on starters in the manufacturer's service manual for the designated tractor.

(or) _____

6 PRACTICE replacing bearings and bushings, starter brushes, starter drive, starter motor solenoid, and turning an armature. Follow the directions in the manufacturer's service manual and INSTRUCTIONS A & B.

7 ARRANGE with your instructor to complete this learning activity package by going through the CHECK- OUT ACTIVITIES listed on page 6.

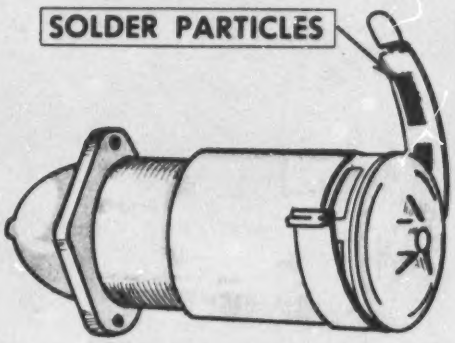



**Figure 1. Thrown solder on cover band indicates starter generator has been overheated.**

**Courtesy of the American Association for Vocational Instructional Materials**

## TOOLS AND EQUIPMENT NEEDED

1. Mechanics Tool Set
2. Bearing Puller
3. Adjustable Reamer

## MATERIALS AND SUPPLIES NEEDED

1. Bearing Lubricant Specified by the Mnaufacturer
2. New Starter Bushings
3. New Starter Drive
4. New Starter Motor Solenoid

## SAFETY

Make sure the battery cable is removed before removing the starter.

## INSTRUCTIONS

### A. SERVICING THE BEARING, BUSHING, AND DRIVES

In replacing bearings and bushings, the following procedure should be used:

1. Disconnect battery ground.
2. Remove starter.
3. Dismantle starter (see manufacturer's service manual for specific directions).
4. Remove bushings with appropriate puller or driver.
5. Install new bushings with appropriate driver.
6. Check for free turning on end of armature shaft.
7. If shaft fits too tightly, ream the bushing until a free fit is obtained.
8. Oil and assemble the starter.
9. Bench test the starter to see that it runs freely without excess play.
10. Reinstall starter and test for proper functioning.

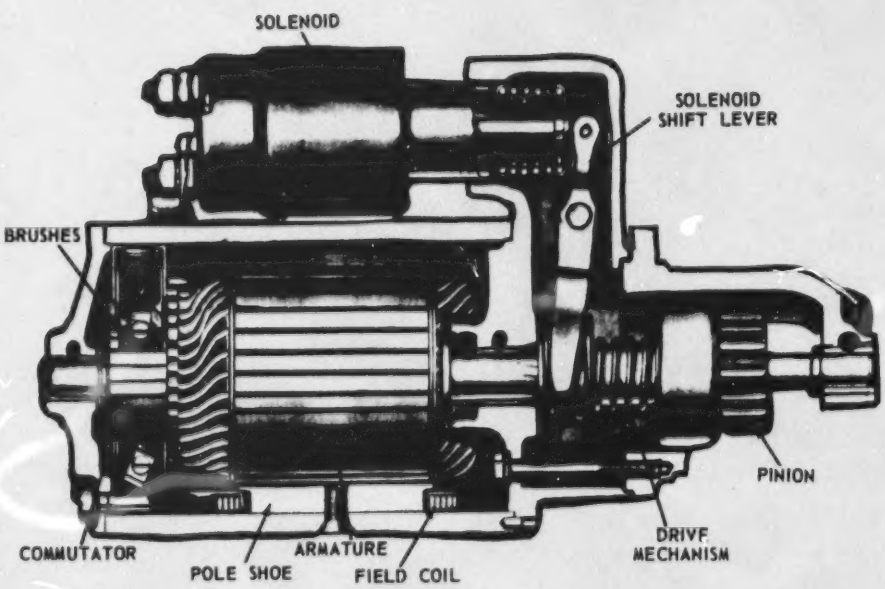



**Figure 2. Cutaway View of a Starting Motor**

Courtesy of John Deere and Company

In replacing starter brushes, the following procedure should be used:

1. Take all brushes out of their retainers and hang them outside of starter frame.
2. Put starter drive-yoke return spring into recess of drive-end housing and install housing to starter frame.
3. Install brush end-plate with end-plate boss aligned with starter-frame slot and install the through bolts. Tighten to 55-75 inch/pounds torque. (Make sure that stop-ring retainer is correctly seated in the drive-end housing.)
4. With a hook, pull back on the brush springs and insert the brushes into their holders.
5. Cover the brush openings with waterproof tape. Install the drive-yoke cover and gasket. Install the brush cover bank and tighten the retaining screw.
6. Lubricate the drive-end of the armature and install drive-end housing seal using a socket or other suitable tool.
7. Connect starter to battery, being careful not to over-tighten cable, and check operation.

Figure 4. Brushes worn to less than half their original length should be replaced.

Courtesy of the American Association for Vocational Instructional Materials

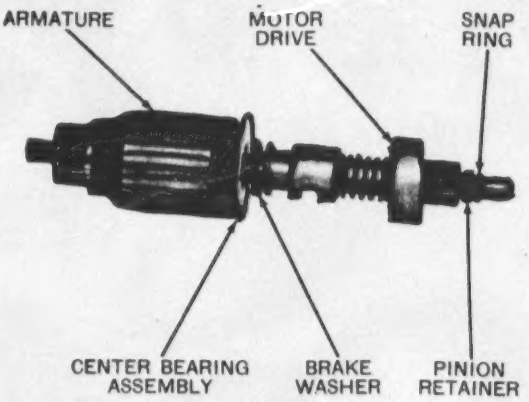



Figure 5. Armature and Drive Assembly

Courtesy of John Deere and Company

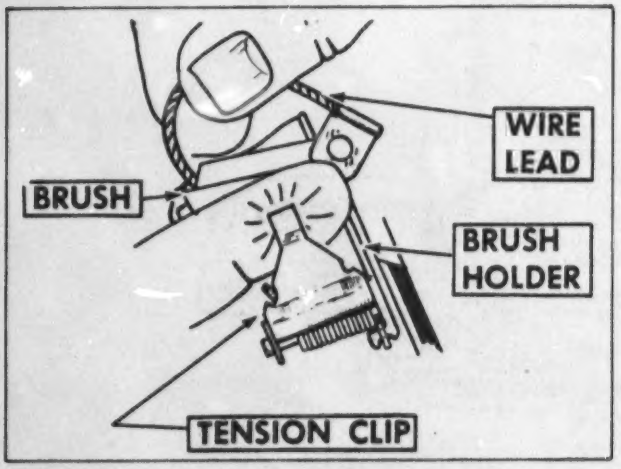



Figure 3. Removing a brush.

Courtesy of the American Association for Vocational Instructional Materials

In replacing the starter drive, the following procedure should be used:

1. Disconnect the battery ground.
2. Remove starter.
3. Remove starter drive (Bendix) from starter shaft.
4. Install new drive on starter shaft; reassemble starter if necessary.
5. Reinstall starter.
6. Reconnect battery ground.
7. Check operation of starter.

INSTRUCTIONS

B. REPLACING THE SOLENOID

In replacing a starter motor solenoid, the following procedure should be used:

1. Remove the starter components as outlined in the service manual, identifying parts during disassembly to facilitate reassembly.

2. Unsolder the contact post from the field-coil connecting strap, using a heavy duty soldering iron or a small flame propane torch.

3. Cut off the head of the contact-spring retaining rivet with a sharp chisel and throw away the contact spring. (Use an 8/32" N.C. tap to cut threads in the rivet hole.)

4. Remove the contact-post retaining screw and insulating washer; discard both.

5. Put the new contact spring and ground brush assembly, paper insulator, and contact post in position on the starter frame.

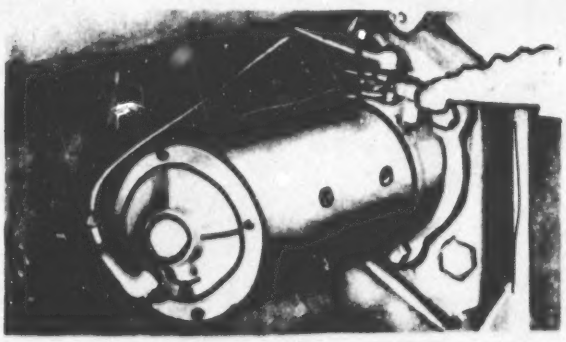


Figure 6. Coaxial Starting Motor with Enclosed Solenoid

Courtesy of John Deere and Company

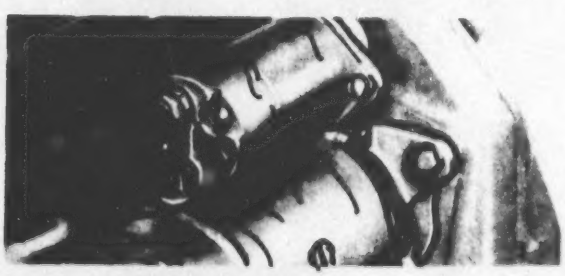


Figure 7. Starting Motor with External Solenoid

Courtesy of John Deere and Company

6. Install the insulating washer and retaining screw. Center the contact points and tighten the retaining screw securely. Stake the threaded end of the screw from inside the starter frame to manufacturer's specifications.

7. Clean the end of the field connecting strap and the slotted area of the contact post with fine sandpaper.

8. Insert the end of the field connector strap through the slot of the contact post and bend the end of the connector strap against the clean surface of the contact post.

9. Solder the connection with rosin-core solder.

10. Remove the upper-ground-brush retaining screw and discard the brush.

11. Place the field-ground lead terminal and new ground-brush terminal block together and install the original retaining screw.

12. Install the armature and drive assembly, drive yoke, and drive-yoke pivot pin. Add a few drops of oil to both ends of the armature shaft.

13. Slide the stop-ring retainer into place on the armature shaft and position the drive-yoke return spring in the drive-end housing; then install the housing to the starter frame.

14. Press on the starter drive yoke until the movable pole shoe is bottomed. Check the clearance between the new contact points and adjust to a .020-.100 clearance.

15. Install protective tape over the brush openings of the starter frame, then install the drive-yoke cover and gasket, and the brush-cover band.

16. Install and tighten the brush-cover-band retaining screw.

**STUDENT SELF-CHECK**
*DO NOT WRITE ON THIS PAGE!*
**SERVICING A STARTER**

1. Briefly explain the function of a starter motor.

2. Explain why a starter should not be "cranked" longer than thirty seconds.

3. Starting motor brushes worn to a) 1/3; b) 1/4; c) 1/2; d) 3/4 their length should be replaced.

4. Which of the following should never be used when cleaning a starting motor commutator? a) emery cloth; b) smooth mill file; c) 00 sandpaper.

Compare your answers with the correct responses on this page. Review any incorrect answers before going on to the next Learning Activity.

**CORRECT RESPONSES**

1. The starting motor serves to turn the flywheel to start the engine.
2. A starter "cranked" longer than 30 seconds will become overheated and damaged.
3. c) 1/2
4. a) b)

**CHECK-OUT ACTIVITIES**

The statements below explain the activities you must be able to complete in order to finish this learning activity package. As you go through each activity, your instructor will rate your performance using the Instructor's Final Checklist, SERVICING THE STARTER.

On the designated tractor:

Replace the bearings and bushings.

Replace the starter brushes.

Replace the starter drive.

Replace the starter motor solenoid.

Turn the armature.

DO NOT WRITE ON THIS PAGE

LAP TM–17

Student _____

Date _____

## SERVICING THE STARTER

### Instructor's Final Checklist

Check the student's performance in the following elements of servicing the starter.

Place an X in the appropriate box indicating not accomplished, partially accomplished, or fully accomplished. If, because of special circumstances, the item was impossible to complete, place an X in the "Not Applicable" box.

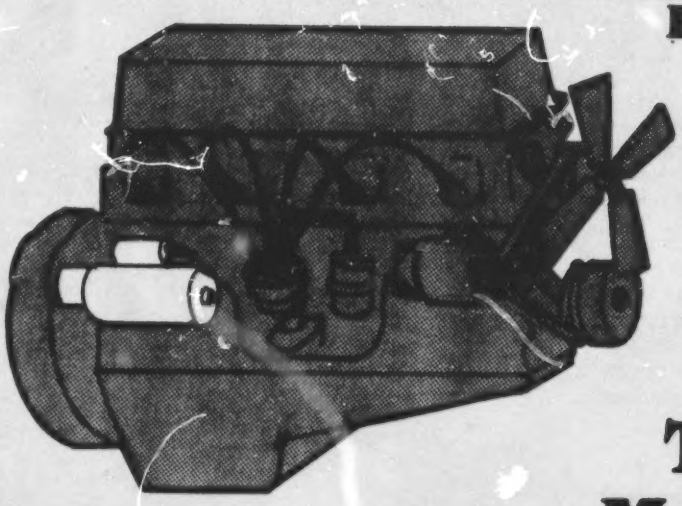
Performance Level: All items must receive a rating of FULLY ACCOMPLISHED (or Not Applicable). If any items are rated Not Accomplished or Partially Accomplished, the student and instructor will discuss this and decide which learning activities must be repeated.

| | Student Performance | | | |
|---|---|---|---|---|
| | Not Applicable | Not Accomplished | Partially Accomplished | Fully Accomplished |
| In servicing the starter, the student: | | | | |
| 1. removed the starter | [ ] | [ ] | [ ] | [ ] |
| 2. dismantled the starter | [ ] | [ ] | [ ] | [ ] |
| 3. removed the starter drive | [ ] | [ ] | [ ] | [ ] |
| 4. installed a new drive | [ ] | [ ] | [ ] | [ ] |
| 5. installed new bushings | [ ] | [ ] | [ ] | [ ] |
| 6. correctly reassembled the starter | [ ] | [ ] | [ ] | [ ] |
| 7. bench tested the starter | [ ] | [ ] | [ ] | [ ] |
| 8. installed and tested the starter on the tractor | [ ] | [ ] | [ ] | [ ] |

# Learning Activity Package Number 18

Objective 74

## Replacing the Starter Motor



Courtesy of the John Deere and Company

## Tractor Mechanics

### INTRODUCTION

Starter motors, properly serviced, will last the lifetime of a tractor. Occasionally a motor may be burned or worn so badly that a new motor will need to be installed. In this learning activity package you will learn how to remove the old starter and install a new one.

### DIRECTIONS

Before you start to work on this learning activity package, be sure you have completed Learning Activity Package 16, "Testing the Starting Circuit," and Learning Activity Package 17, "Servicing the Starter."

If you have completed these Learning Activity Packages, read the objective below. If you feel you are already able to perform this task, read the Check-Out Activity on page 4 of this package. Then, either arrange with your instructor about doing the Check-Out Activity,

or

If you need to complete learning activities in order to be able to do the task, turn to page 2 and go through the Learning Activities in the order given.

### OBJECTIVE

Given an open-end and box-end wrench set, a socket set, and a new starter, replace the starter motor on the designated tractor. The starter will fit correctly, be fastened securely, and all connections will fit tightly.

## LEARNING ACTIVITIES

1 READ INSTRUCTIONS, REPLACING THE STARTER MOTOR.

(or) _____

2 STUDY the section on starters in the manufacturer's service manual.

(or) _____

3 CHECK YOUR KNOWLEDGE by taking Student Self-Check, REPLACING THE STARTER MOTOR.

(or) _____

4 OBSERVE another student as he or she satisfactorily performs and is checked out on this module.

(or) _____

5 PRACTICE removing and reinstalling the starter motor as directed by INSTRUCTIONS and the manufacturer's service manual.

6 ARRANGE with your instructor to complete this learning activity package by going through the CHECK–OUT ACTIVITY on page 4.

## TOOLS AND EQUIPMENT NEEDED

1. Open-End Wrench Set
2. Box-End Wrench Set
3. Socket Set

## MATERIALS AND SUPPLIES NEEDED

1. New Starter

## SAFETY

Remember to disconnect battery ground cable before removing cable from starter.

INSTRUCTIONS

## REPLACING THE STARTER MOTOR

In replacing the starter motor, the following procedure should be used:

1. Disconnect battery ground cable.
2. Disconnect cable from starter.
3. Unbolt starter from engine.
4. Compare old starter with replacement starter to be sure of correct fit.
5. Thoroughly clean mount area for good grounding.
6. Bolt on replacement starter.
7. Replace starter cable.
8. Replace battery ground cable.
9. Check for correct operation.

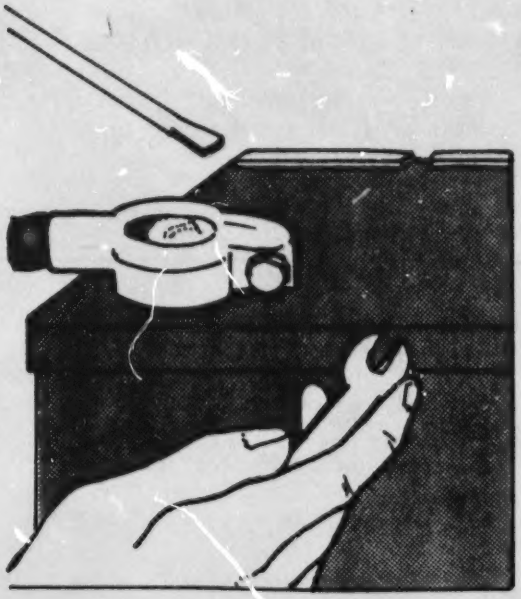


Figure 1. Disconnect battery ground cable

Figure 3. Unbolt starter from engine

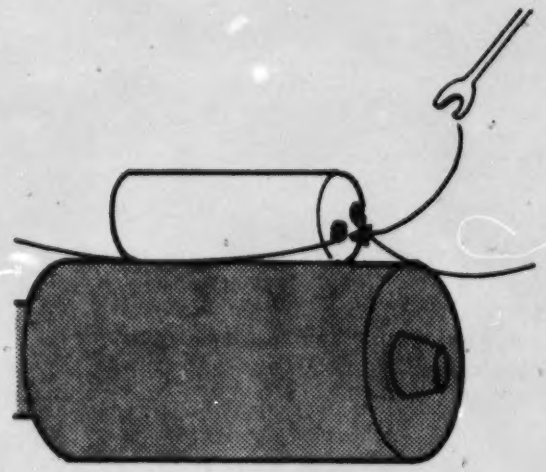


Figure 2. Disconnect cable from starter

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**STUDENT SELF-CHECK**
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**REPLACING THE STARTER MOTOR**

1. Briefly explain why the ground cable must be disconnected before any work on the starter is attempted.

2. Arrange the steps listed in the correct order for replacing the starter.

   A Replace battery ground cable.

   B Replace starter cable.

   C Bolt on replacement starter.

   D Disconnect cable from starter.

   E Disconnect battery ground cable.

   F Check for correct operation.

   G Thoroughly clean mount area for good grounding.

   H Compare old starter with replacement starter to be sure of correct fit.

   I Unbolt starter from engine.

**CORRECT RESPONSES**

2. 1. E
   2. D
   3. I
   4. H
   5. G
   6. C
   7. B
   8. A
   9. F

1. The ground strap must be disconnected in order to prevent accidental starting of the engine and to prevent burns from accidental short circuits.

**CHECK-OUT ACTIVITIES**

The statement below explains the activity you must be able to complete in order to finish this learning activity. As you go through the activity, your instructor will rate your performance using the Instructor's Final Checklist, REPLACING THE STARTER MOTOR.

Replace the starter motor on the designated tractor.

DO NOT WRITE ON THIS PAGE

LAP TM–18

Student _____

Date _____

## REPLACING THE STARTER MOTOR

### Instructor's Final Checklist

Check the student's performance in the following elements of replacing the starter motor.

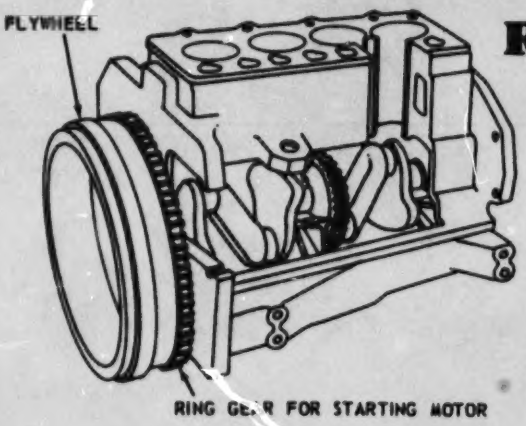
Place an X in the appropriate box indicating not accomplished, partially accomplished, or fully accomplished. If, because of special circumstances, the item was impossible to complete, place an X in the "Not Applicable" box.

Performance Level: All items must receive a rating of FULLY ACCOMPLISHED (or Not Applicable). If any items are rated Not Accomplished or Partially Accomplished, the student and instructor will discuss this and decide which learning activities must be repeated.

| | | Student Performance | | | |
|---|---|---|---|---|---|
| | | Not Applicable | Not Accomplished | Partially Accomplished | Fully Accomplished |
| When replacing the starter motor, the student: | | | | | |
| 1. | disconnected starter | [ ] | [ ] | [ ] | [ ] |
| 2. | removed starter from engine | [ ] | [ ] | [ ] | [ ] |
| 3. | installed new starter | [ ] | [ ] | [ ] | [ ] |
| 4. | replaced cable and ground | [ ] | [ ] | [ ] | [ ] |
| 5. | checked correct operation | [ ] | [ ] | [ ] | [ ] |

# Learning Activity Package Number 19

Objective 70




Courtesy of John Deere and Company

# REPLACING THE RING GEAR ON A FLYWHEEL

## Tractor Mechanics

### INTRODUCTION

Farm tractors have ring gears on the flywheel to work with the starter motor and on the rear axle to work with the drive shaft. A ring gear is simply a mechanical device which allows power to continue as the tractor turns a corner. After repeated engagement of the starter, the ring gear on the flywheel may have excessively worn or even broken teeth, causing slippage or failure of the starter to properly engage and turn the engine over. The condition of the ring gear can be determined easily by visual inspection. In this learning activity package you will learn how to replace the ring gear on a flywheel.

### DIRECTIONS

Read the objectives below. If you believe you are already able to perform these tasks, read the Check-Out Activities on page 4 of this package. Then, either arrange with your instructor about doing the Check-Out Activities,

or,

If you need to complete learning activities in order to be able to do the task, turn to page 2 and go through the Learning Activities in the order given.

### OBJECTIVE

Given ring gear, complete tool set, and oven or torch to heat the ring gear, replace the ring gear on the flywheel of the designated tractor. The ring gear will be installed without damage to any other parts and the starter will engage properly.

## LEARNING ACTIVITIES

1 READ *Fundamentals of Service–Engines* (John Deere Company), pp. 2 - 61 and 2 - 62.

(or) _____

2 READ INSTRUCTIONS, REPLACING THE RING GEAR ON A FLYWHEEL.

(or) _____

3 CHECK YOUR KNOWLEDGE by taking Student Self-Check, REPLACING THE RING GEAR ON A FLYWHEEL.

(or) _____

4 STUDY the section on installing ring gears in the manufacturer's service manual.

(or) _____

5 PRACTICE removing and reinstalling the ring gear on the flywheel of a tractor. Follow the directions in the manufacturer's service manual and Instructions.

6 ARRANGE with your instructor to complete this learning activity package by going through the CHECK-OUT ACTIVITIES listed on page 4.

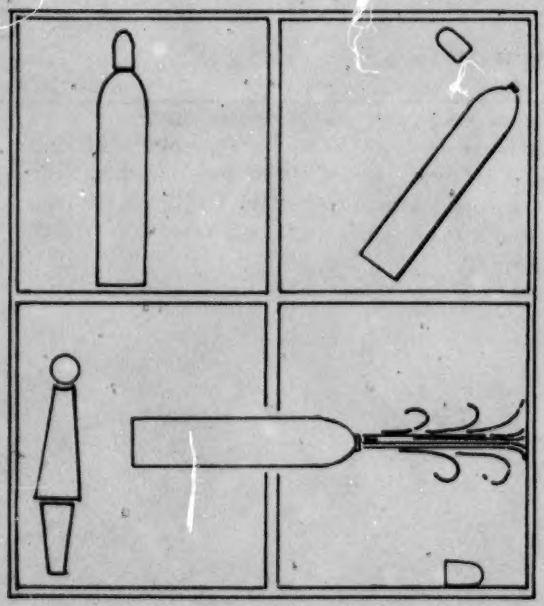


Figure 1. Oxygen tanks are pressurized and dangerous if top is broken off.

Figure 2. Iron filings from chain hoist are hazardous to eyes–wear eye protection.

## TOOLS AND EQUIPMENT NEEDED

1. Set of Mechanic's Tools
2. Floor Jack or Hoist
3. Jack Stands
4. Oxy-Acetylene torch

## MATERIALS AND SUPPLIES NEEDED

1. Ring Gear for Tractor Being Used.
2. I & T Shop Manual on Tractor Being Repaired

## SAFETY

Make certain the tractor sections are secured with floor jacks or chain hoist. Wear eye protections when operating the chain hoist (filings from the chain can fall in the eye). Exercise all precautions relating to the use of an oxy-acetylene welder.

INSTRUCTIONS

## REPLACING THE RING GEAR ON A FLYWHEEL

1. Separate the motor section from the transmission and drive sections. Read very carefully the section in the I & T shop manual on the tractor being used to determine the procedure necessary to perform this task. On some tractors, the ring gear can be removed without removing the clutch, pressure plate, and flywheel.

2. Take a chisel and hammer and begin at one point on flywheel and hammer with sharp blows around the entire wheel. The ring gear should come off.

3. If not successful with the chisel and hammer in removing the gear, use the oxy-acetylene torch to cut it off. Care must be taken in the use of any piece of equipment not to damage the flywheel.

4. After removal of old ring gear and cleaning of flywheel, install the new ring gear.

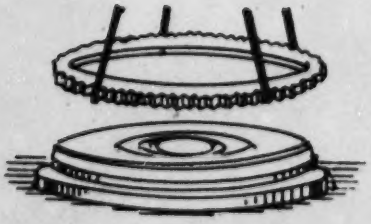


Figure 3. Attaching the heated ring gear onto the flywheel.

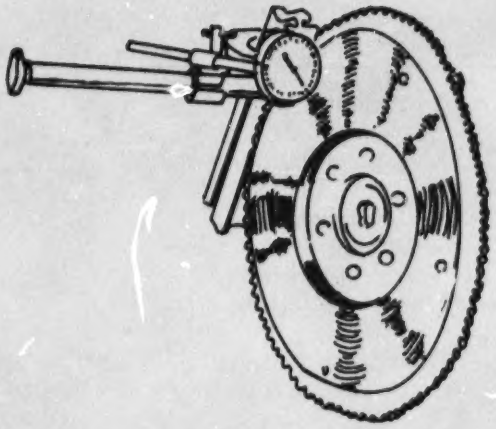


Figure 4. Checking flywheel clutch disc contact surface

5. Place the new ring gear on fire brick, and by using a neutral flame on oxy-acetylene torch, heat ring gear uniformly. This will cause it to expand. Do not heat until it changes color.

6. After ring gear is heated, take pliers or welding clamps and place new ring gear on flywheel. (Round end of teeth go toward starter)

7. Take a ball peenhammer and tap lightly, making sure it is seated on flywheel.

8. After it cools and tightens up, hammer lightly again to insure proper seatings.

9. Reinstall flywheel, if removed, and other clutch parts.

10. Reassemble the two sections of the tractor.

**STUDENT SELF-CHECK**
*DO NOT WRITE ON THIS PAGE!*
**REPLACING THE RING GEAR ON A FLYWHEEL**

1. The ring gear meshes with the _____ to ensure starting.

   a. generator
   b. alternator
   c. starter
   d. distributor

2. A damaged ring gear can result in _____.

   a. starter slippage
   b. failure to start
   c. starter locking down
   d. all of the above

3. The reason for heating ring gear before trying to place it on the flywheel is:

   a. It makes ring gear harder.
   b. It cleans grease off of gear.
   c. It causes it to expand.
   d. None of the above.

Compare your answers with the correct responses on this page. Review any incorrect answers before going on to the next Learning Activity.

**CORRECT RESPONSES**

3. c

2. d

1. c

**CHECK-OUT ACTIVITIES**

The statement below explains the activity you must be able to complete in order to finish this learning activity package. As you go through the activity, your instructor will rate your performance using the Instructor's Final Checklist, REPLACING THE RING GEAR ON A FLYWHEEL.

In the shop area, replace a ring gear on the flywheel of the designated tractor.

DO NOT WRITE ON THIS PAGE

LAP TM–19

Student _____

Date _____

## REPLACING THE RING GEAR ON A FLYWHEEL

### Instructor's Final Checklist

Check the student's performance in the following elements of replacing the ring gear on a flywheel.

Place an X in the appropriate box indicating not accomplished, partially accomplished, or fully accomplished. If, because of special circumstances, the item was impossible to complete, place an X in the "Not Applicable" box.

Performance Level: All items must receive a rating of FULLY ACCOMPLISHED (or Not Applicable). If any items are rated Not Accomplished or Partially Accomplished, the student and instructor will discuss this and decide which learning activities must be repeated.

| | Student Performance | | | |
|---|---|---|---|---|
| | Not Applicable | Not Accomplished | Partially Accomplished | Fully Accomplished |
| In replacing the ring gear, the student: | | | | |
| 1. removed flywheel | [ ] | [ ] | [ ] | [ ] |
| 2. removed old ring gear without damaging the flywheel | [ ] | [ ] | [ ] | [ ] |
| 3. reinstalled ring gear on flywheel | [ ] | [ ] | [ ] | [ ] |
| 4. reinstalled flywheel so that starter engaged correctly | [ ] | [ ] | [ ] | [ ] |